Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

MAY, 1957

TECHNOLOGY DEPT.

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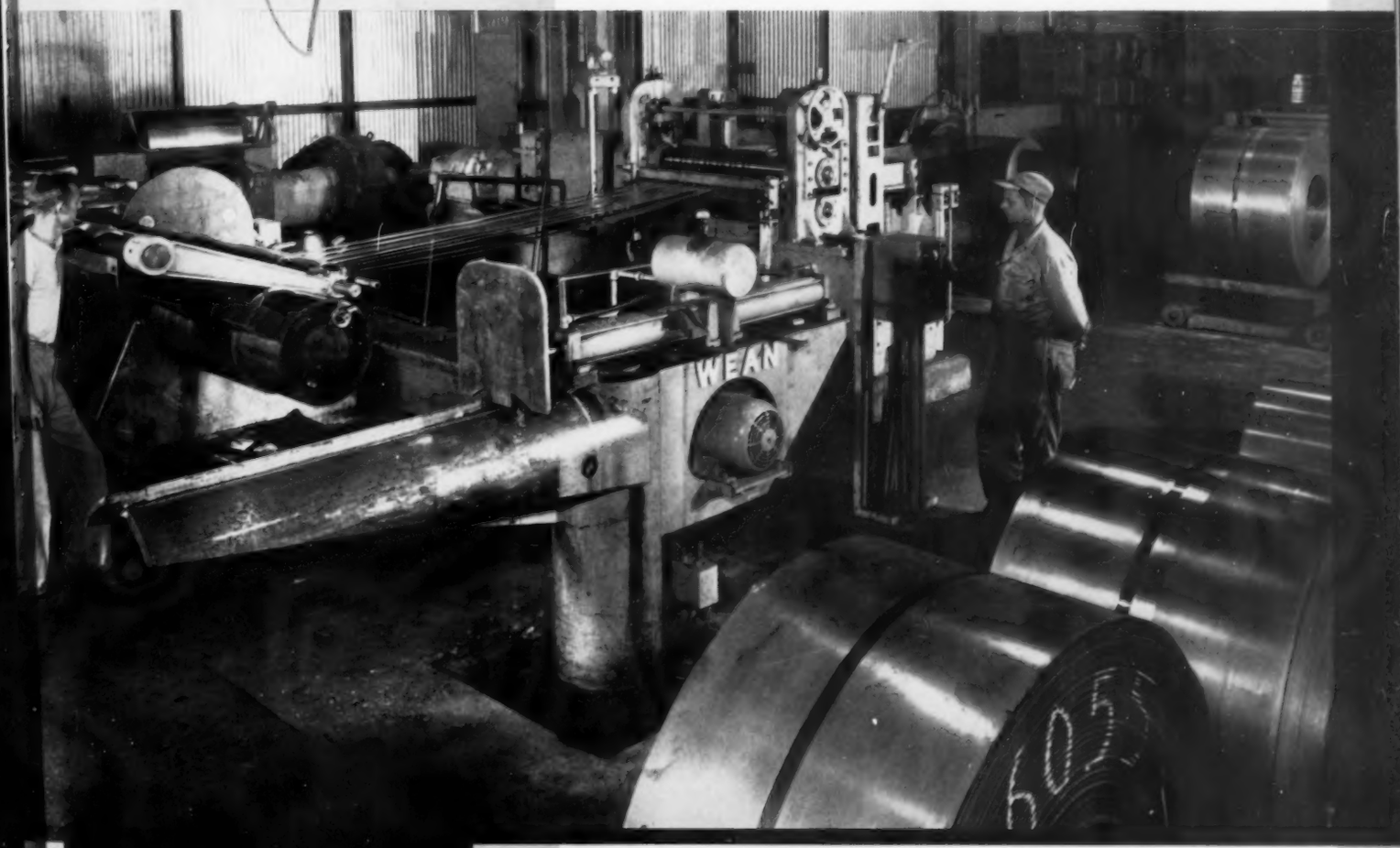
DETROIT

Slitting is faster, more accurate because of

WEAN

CREATIVE ENGINEERING



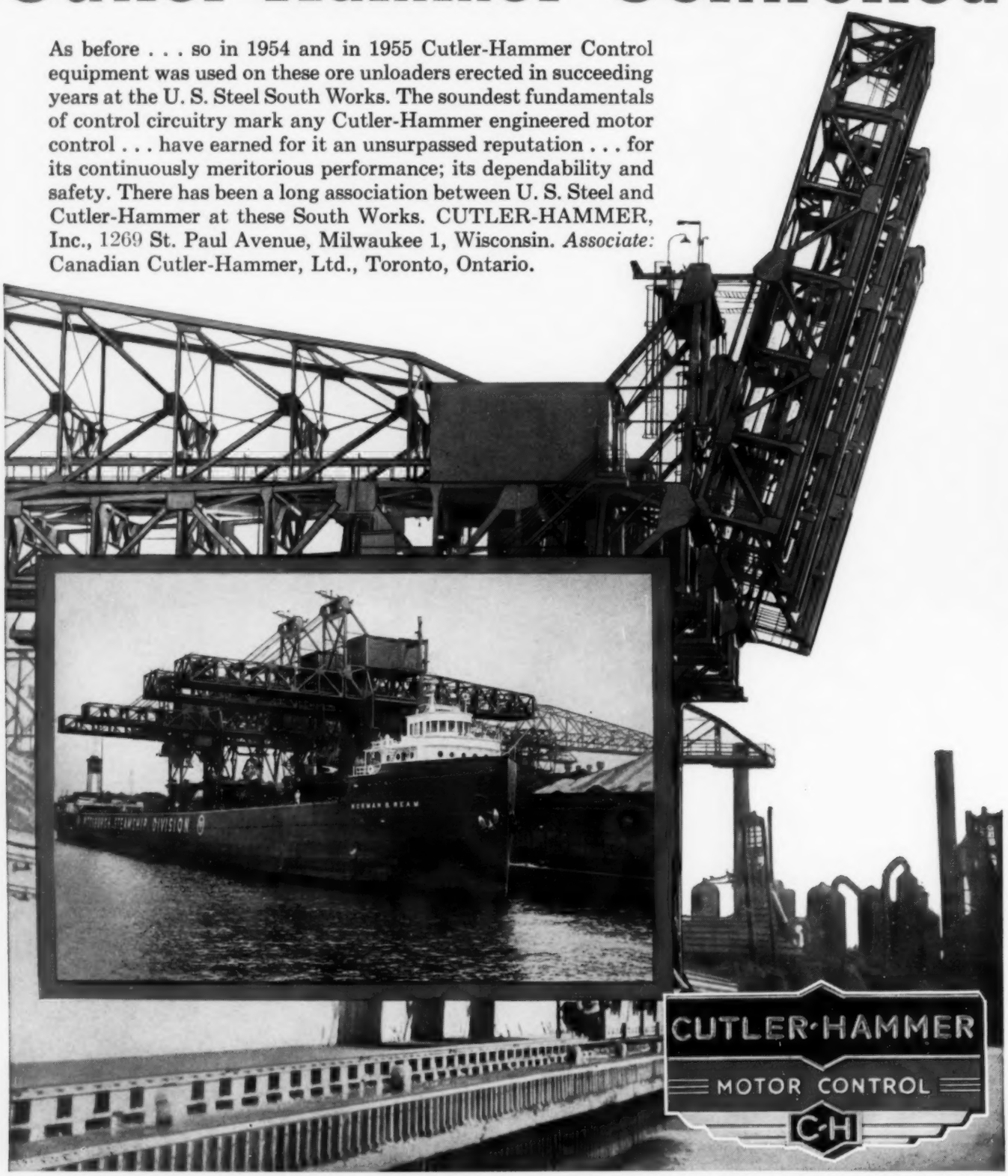
160A

WEAN

● Wean high speed slitting lines are being used by more and more of the nation's steelmakers because they are engineered to perform the most accurate slitting job at cost reducing speeds. And, auxiliary coil handling equipment is designed to keep the steel moving — to get maximum production from the line at all times. If slitting is part of your operation, get the last word on high production slitting from Wean engineers before you buy.

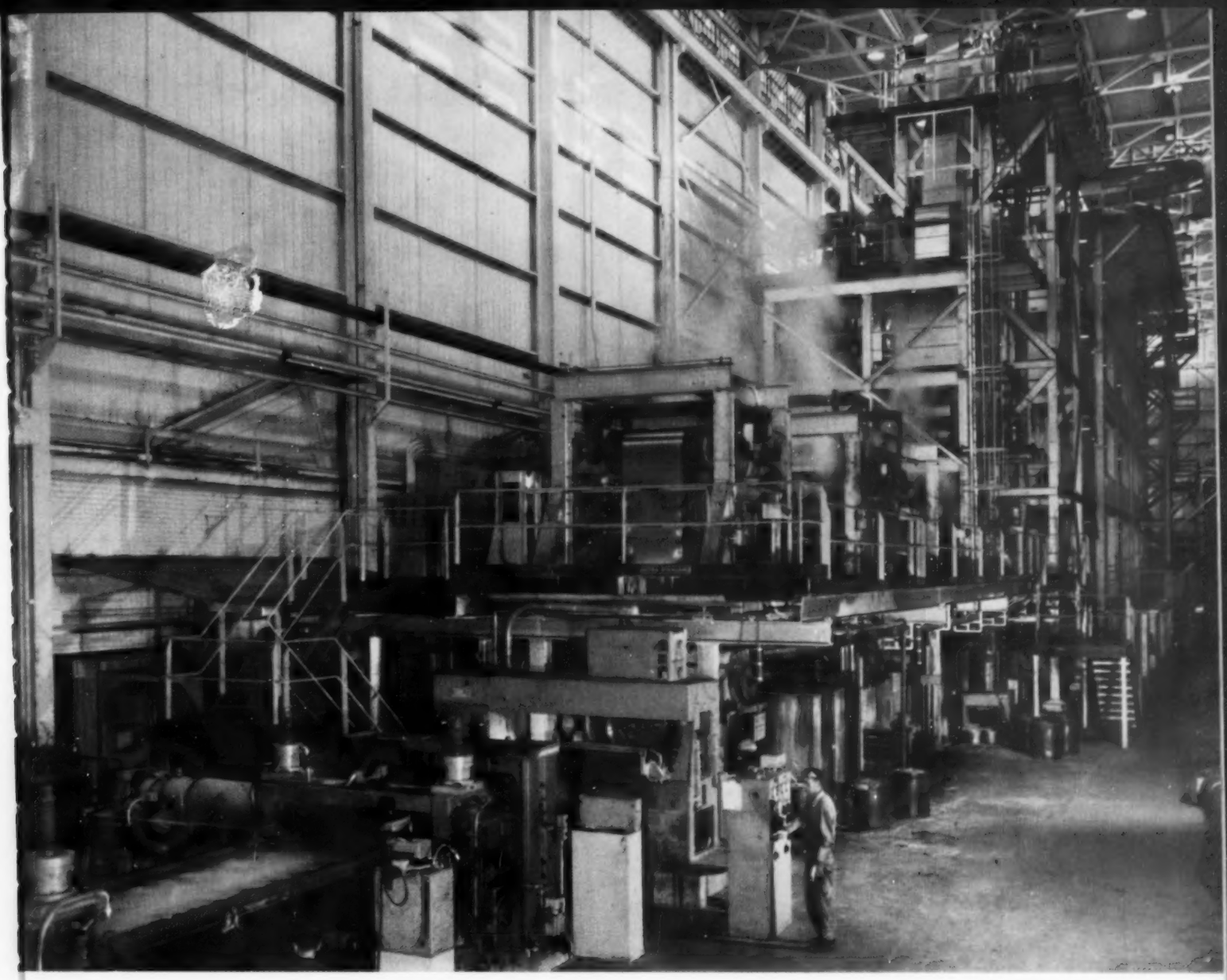
SEVEN GIANTS
at USS South Works
Cutler-Hammer Controlled

As before . . . so in 1954 and in 1955 Cutler-Hammer Control equipment was used on these ore unloaders erected in succeeding years at the U. S. Steel South Works. The soundest fundamentals of control circuitry mark any Cutler-Hammer engineered motor control . . . have earned for it an unsurpassed reputation . . . for its continuously meritorious performance; its dependability and safety. There has been a long association between U. S. Steel and Cutler-Hammer at these South Works. CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.



LOOK TO CUTLER-HAMMER MILL EXPERIENCE . . . AS BROAD AS IT IS LONG

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers at 20th and Northampton Sts., Easton, Pa. Editorial and advertising offices, 1010 Empire Bldg., Pittsburgh 22, Pa. Entered as second class matter at Easton, Pa.



Continuous ANNEALING LINES...

• This is one of several Continuous Annealing Lines designed and built by Aetna-Standard. The line processes 48" wide strip maximum at 1000 feet a minute at Dominion Foundries and Steel, Limited, Hamilton, Ontario, Canada. This line has been designed so that the Annealing Furnace can be bypassed and strip run through for cleaning only.

Like Continuous Galvanizing or Tinning, a Continuous Annealing Line requires efficient design and rugged equipment. As a pioneer in Continuous Lines and other equipment for processing sheet and strip, Aetna has broad experience in the design of equipment required for your specific application.

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1. Firing Circuit

A small dc excitation arc is automatically ignited only once, when the unit is started. It is then maintained on the mercury cathode of each rectifier tube. It offers advantages similar to a pilot light. Since it is far easier to maintain an arc than to start it, this feature reduces the chance of the excitron losing excitation during power supply disturbances.

2. Phase Control Circuit

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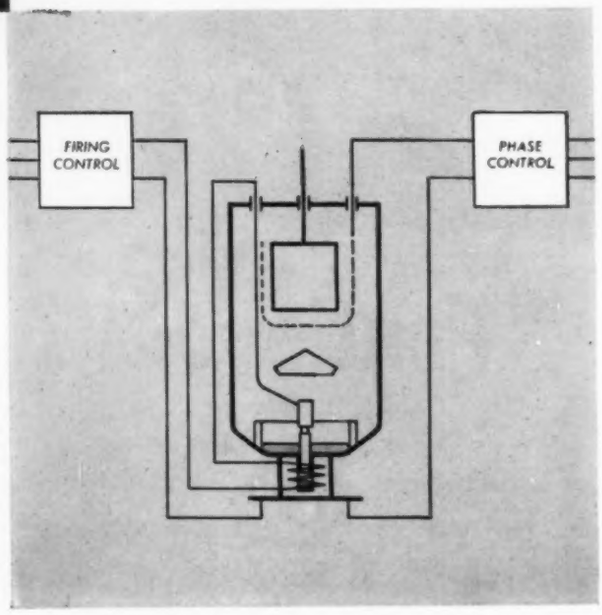

Only Excitron Rectifiers Provide Separate Circuits

for these two all-important functions. Improved operation results — one function is never sacrificed for the other — you get optimum operation from each.

For Complete Information on rectifier operation, call your nearby A-C office, or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

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Iron AND Steel ENGINEER

MAY, 1957 VOLUME XXXIV NUMBER V

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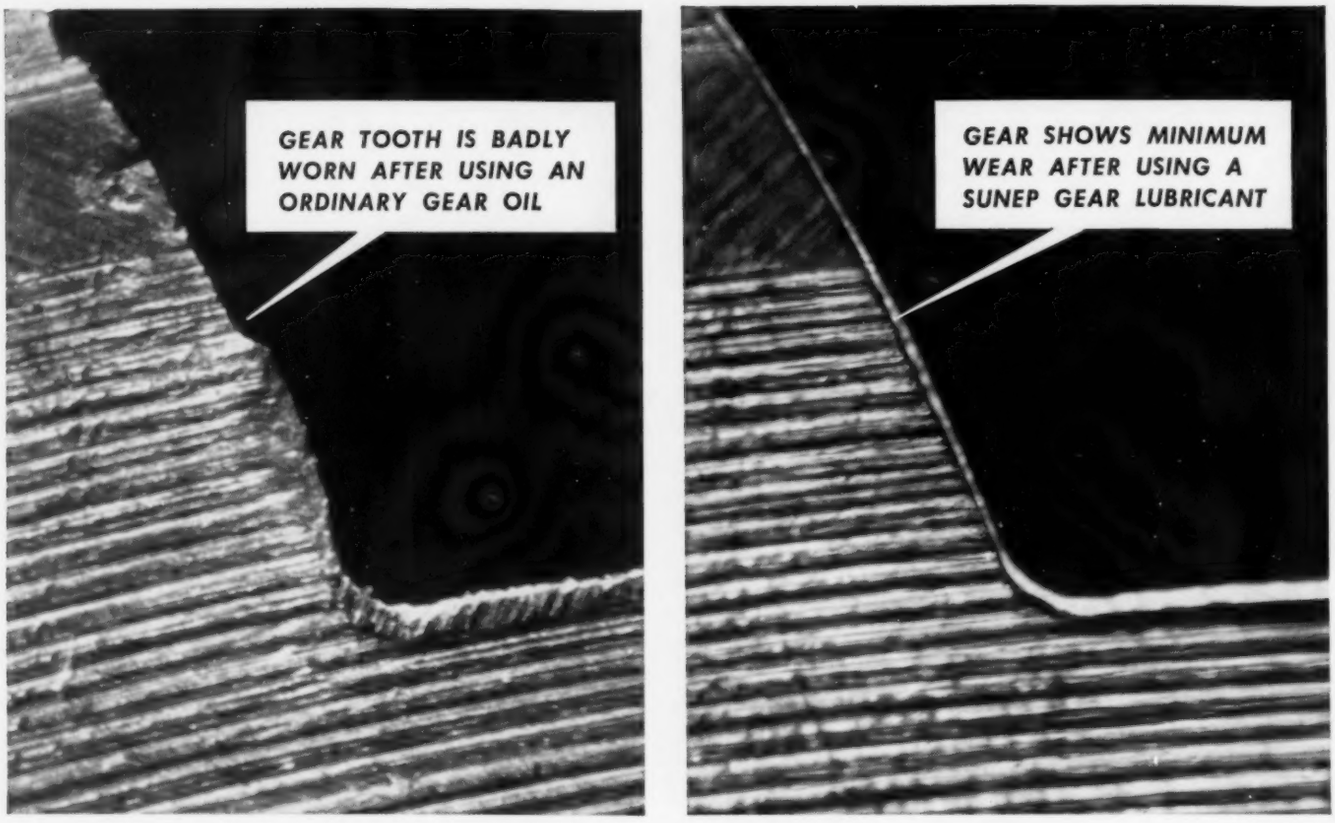

COMPARATIVE TESTS on identical new worm gears demonstrate superiority of Sunep Gear Lubricant. Gear on left, using a compounded cylinder oil, shows excessive wear at 70 hours. Gear on right, protected by Sunep, shows minimum wear after running over 200 hours!

HERE'S PROOF SUNEP GEAR LUBRICANTS MINIMIZE WEAR

Sunep Gear Lubricants cut power losses...protect against overloads ...lengthen gear life...reduce maintenance costs and replacements.

During recent tests gear units protected by Sunep Gear Lubricant showed an absolute minimum of wear when run at normal rated capacity. There was no indication of scoring or wear even when run at overloads up to 118%! Power consumption was reduced up to 25%. Damage from shock loads was nil.

In addition to outstanding load-carrying ability, Sunep Gear Lubricants are extremely stable, non-corrosive, prevent rusting, keep gears and bearings clean.

For complete information about how Sunep Gear Lubricants can help give longer life to your worm gear units, see your Sun representative...or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. IS-5.

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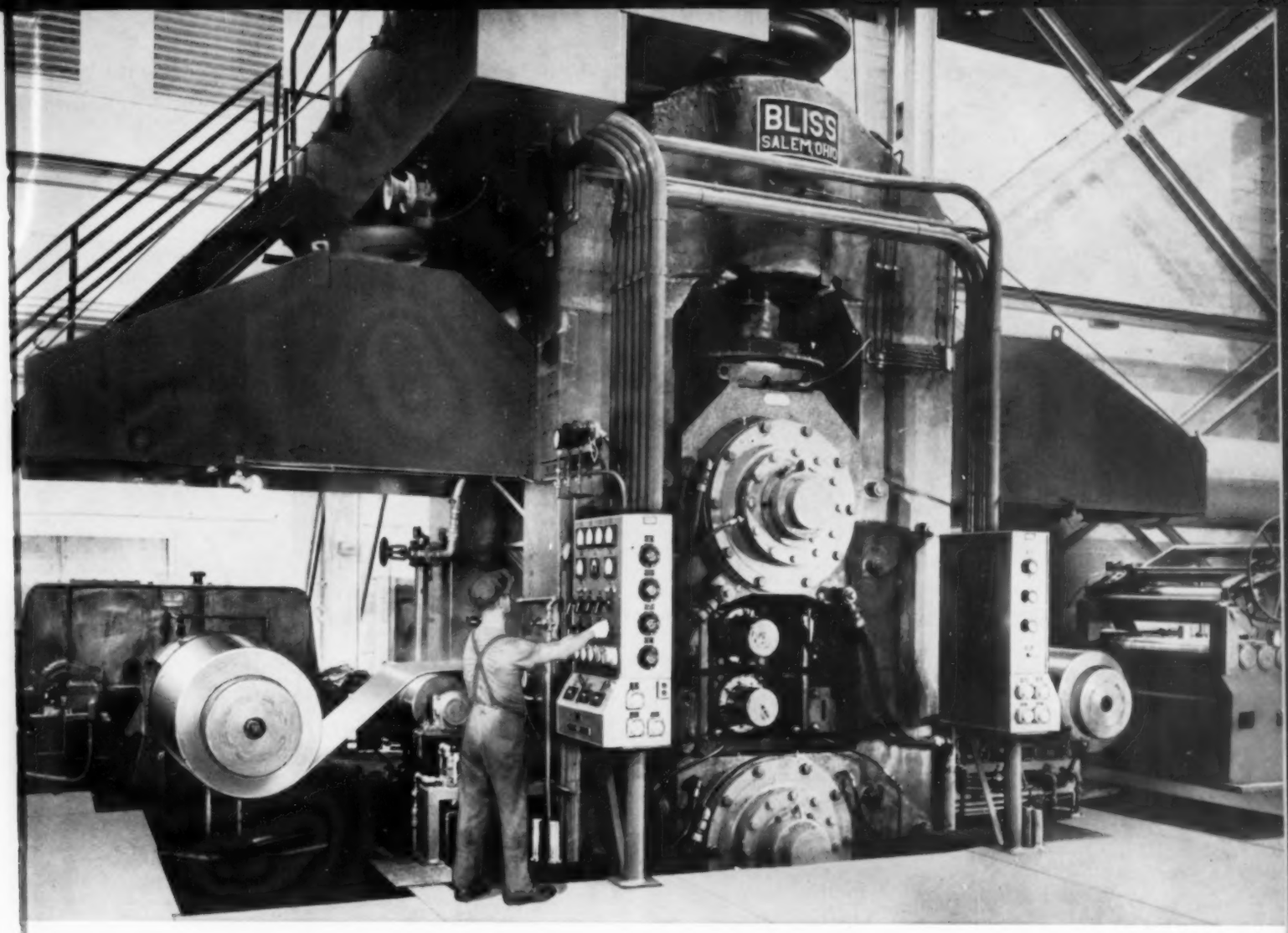

Acme-Newport Steel's 48-inch reversing cold mill with 3000 hp main mill motor is CLARK CONTROLLED

Clark control panel for reel and main drive motors, payoff reel motor, screwdown motors, and supporting motor generator.

Clark control center for mill auxiliaries.

This 18 & 49 x 56-inch single-stand, four-high Bliss reversing cold mill is powered by Elliott drives with Clark control. The mill can handle 48-inch wide coils of hot-rolled pickled strip weighing up to 40,000 lbs.

Besides the 3000 hp main mill motor, the mill has two 1000 hp reel motors, a 100 hp uncoiler drive motor and two 50 hp screwdown motors, all Clark controlled. Reel and screwdown motors have Clark DC brakes.

Clark control, combined with Elliott rotating equipment provides uniform acceleration from 0 to 1775 fpm. Speed control is continuous and uniform. The same constant strip tension is maintained during acceleration and deceleration as during normal rolling speed.

This is another example of a critical processing operation in the basic steel industry successfully controlled by Clark engineered apparatus. *Let us help you solve your control problems.*

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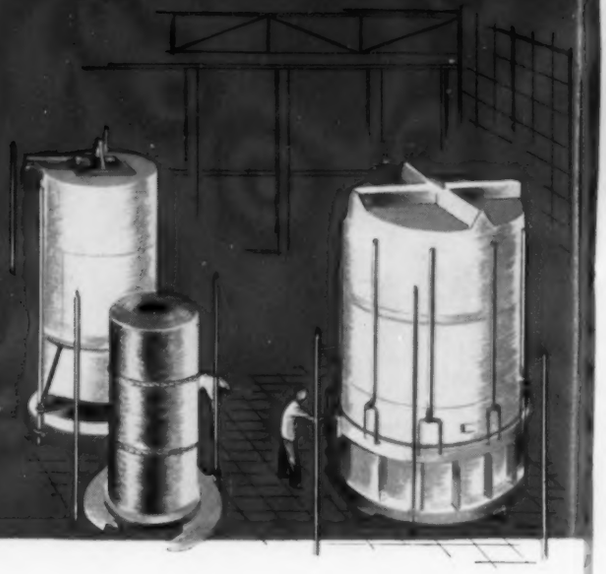
Customer's Report



"Quality beyond expectation, operating conditions best ever since we switched to remote control Lee Wilson Furnaces"

• "Only Lee Wilson Single Stacks offered up-to-date operating conditions — and, this was another reason we switched to these furnaces when we expanded our annealing facilities," a cold mill superintendent for a leading strip producer told us recently. This statement is, indeed, fact — for *only* Lee Wilson Single Stacks enable operators to thoroughly and exactly control furnace temperatures from modern remote control centers. This results in faster, more uniform annealing, and makes the operators job cleaner, easier and safer.

This is just one of many reasons why Lee Wilson Single Stack is preferred over all others in modern annealing practice.

Only Lee Wilson Furnaces Give You All These Advantages

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2. MORE UNIFORM HEAT APPLICATION
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4. HIGHER PRODUCTION
5. BETTER LOAD FACTOR
6. MINIMUM PROCESS INVENTORY
7. REDUCED LABOR COST
8. BETTER OPERATING CONDITIONS
9. LOWER MAINTENANCE COST
10. REDUCED INSTALLATION COSTS

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MAKE THE BEST METALS BETTER

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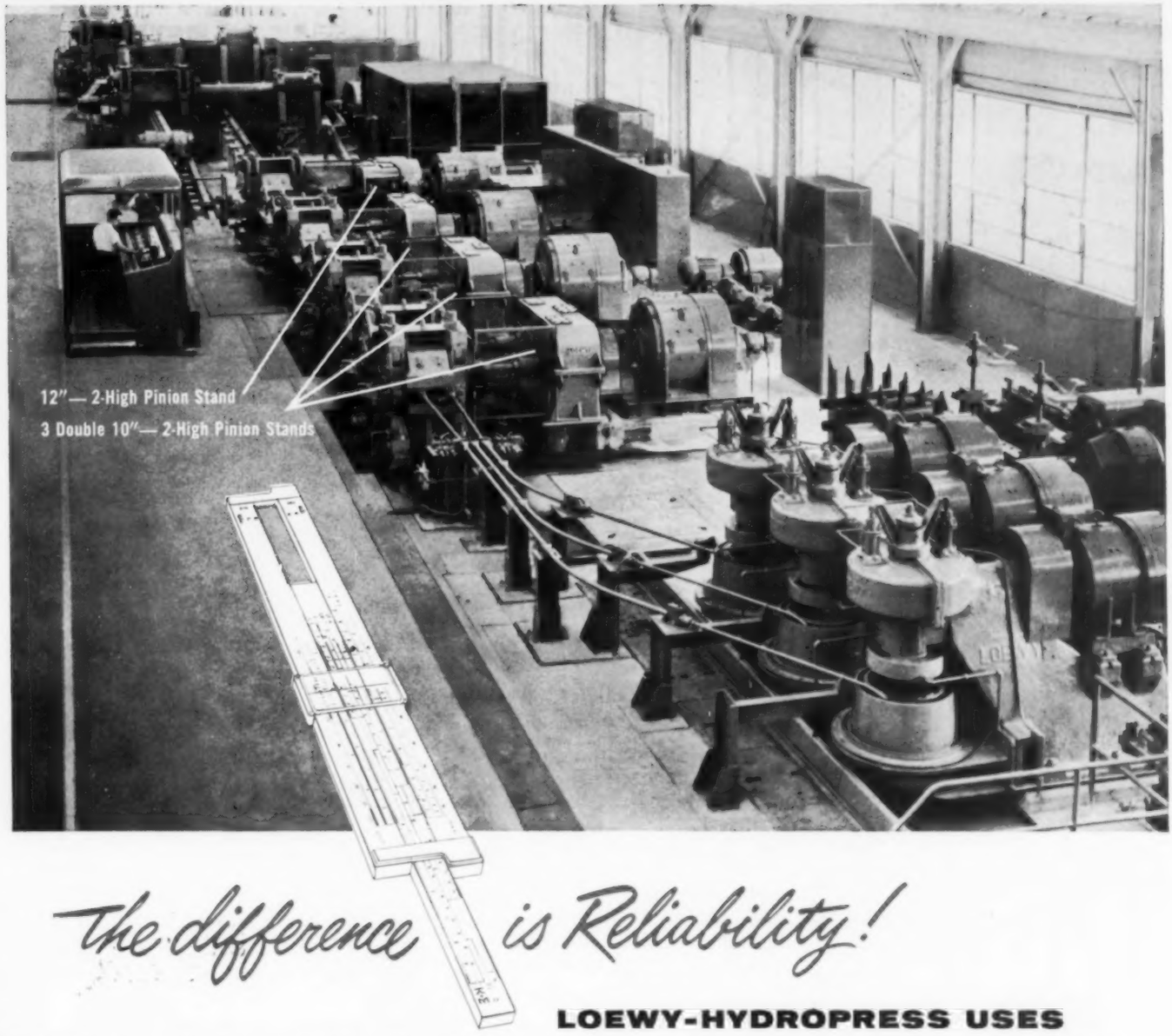
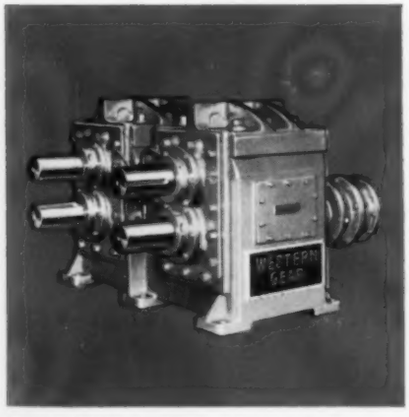


the difference is Reliability!

LOEWY-HYDROPRESS USES

WESTERN GEAR PINION STANDS FOR NEW COPPER WIRE ROD MILL



Typical Western Gear pinion stand, available in capacities to 2000 HP.

When the Loewy-Hydropress division of Baldwin-Lima-Hamilton Corporation designed and built an important installation for a leading manufacturer of electric cable, they selected Western Gear pinion stands. Company engineers knew that our years of experience and service to the steel industry would result in units engineered to suit the specific requirements of power and speed, type and gauge of metal, nature of load, and type of drive motor. Western Gear pinion stand designs incorporate special "Hy-Q"* precision gears and pinions, liberal size shafts, conservatively selected anti-friction bearings, and rigidly constructed gear cases in order to insure dependable trouble-free operation.

So, if yours is a project involving modernization or the construction of a new mill, ask Western Gear specialists to help you. You'll get the benefit of mechanical power transmission experience gained since 1888 to help solve your problem, efficiently and economically. Address General Offices, Western Gear, P.O. Box 182, Lynwood, California.

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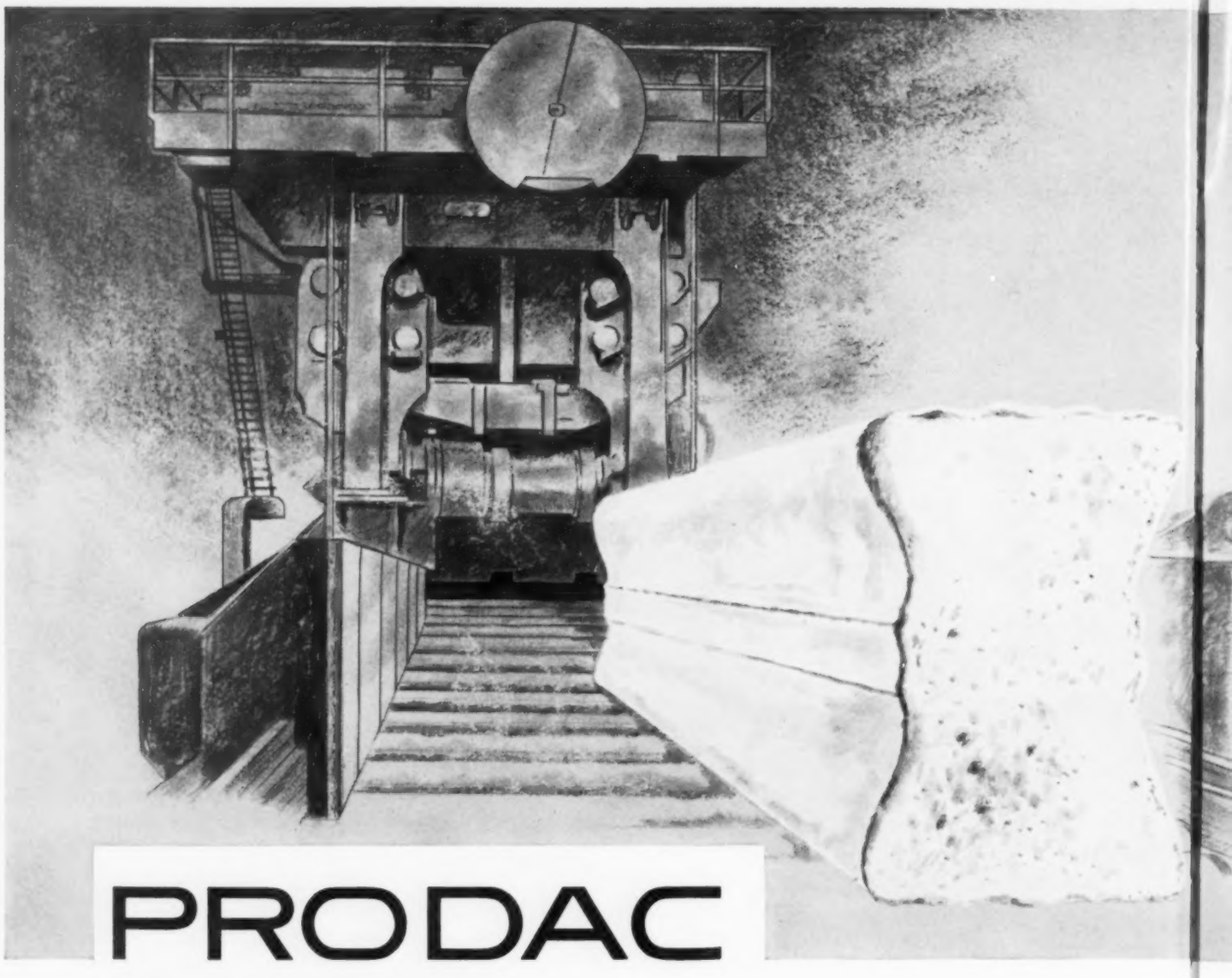

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PROGRAMMED DIGITAL AUTOMATIC CONTROL

a revolutionary new steel mill control by Westinghouse

With Westinghouse PRODAC*, the full capacity of mill equipment can be utilized. This revolutionary new mill control now makes possible a consistent capacity production rate with positive accuracy in operation.

Through the card programmed system, mill operation is completely predetermined. To initiate a rolling schedule, the operator just feeds in the pre-punched "reader" cards. He then pushes a button, and the control automatically runs the mill, makes the necessary number of passes, and provides continuing adjustment of mill speed and screwdown opening.

To find out how Westinghouse Systems Control Engineering can apply PRODAC to your mill operation, call your Westinghouse representative. Or, write Westinghouse Electric Corporation, 3 Gateway Center, Pittsburgh 30, Pennsylvania.

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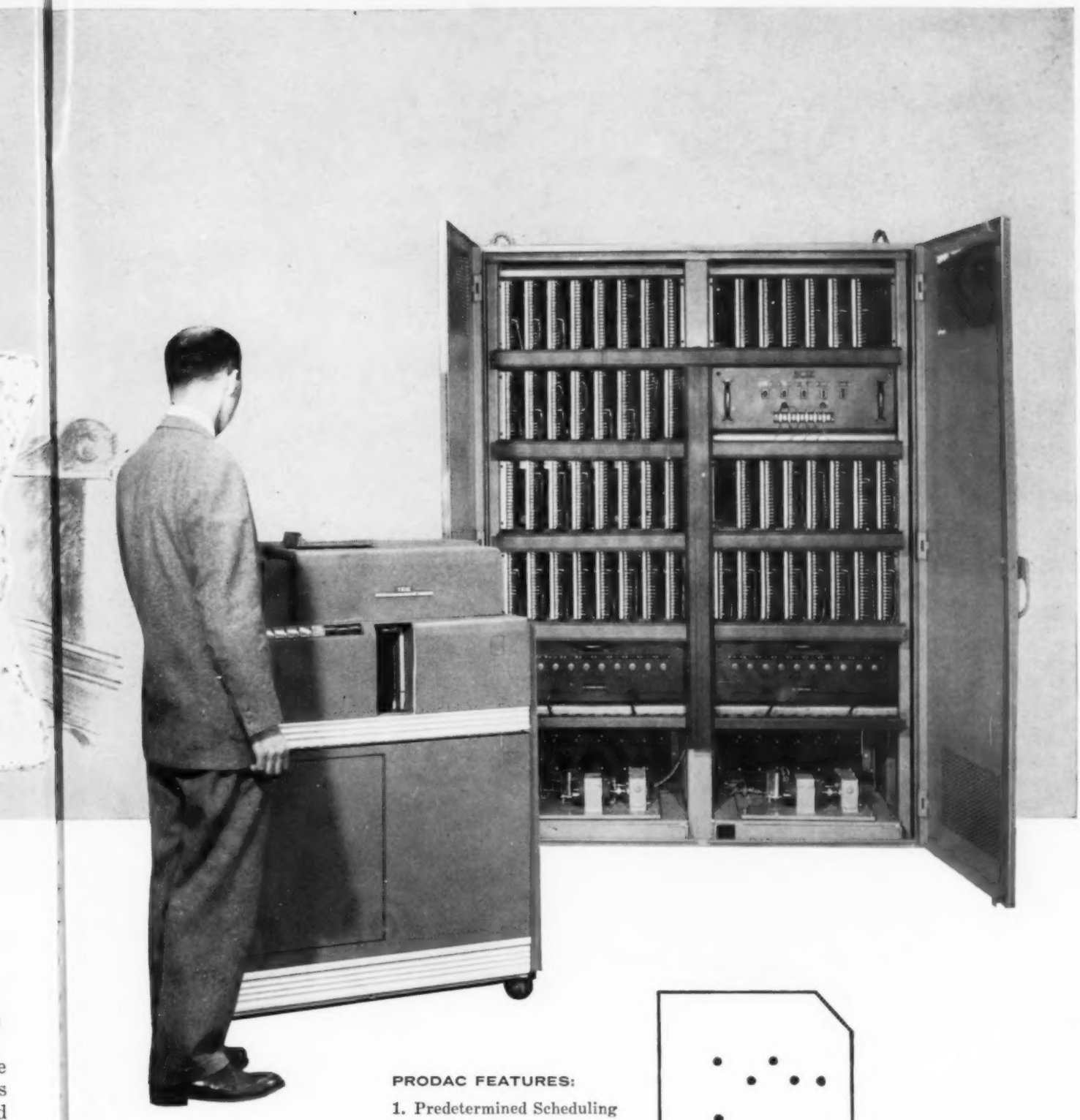
YOU CAN BE SURE...IF IT'S Westinghouse



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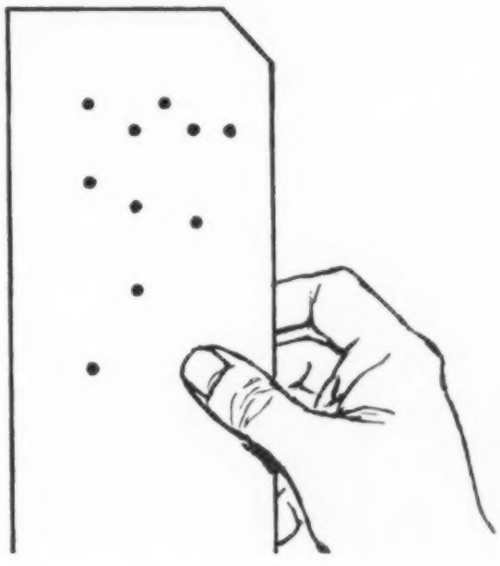

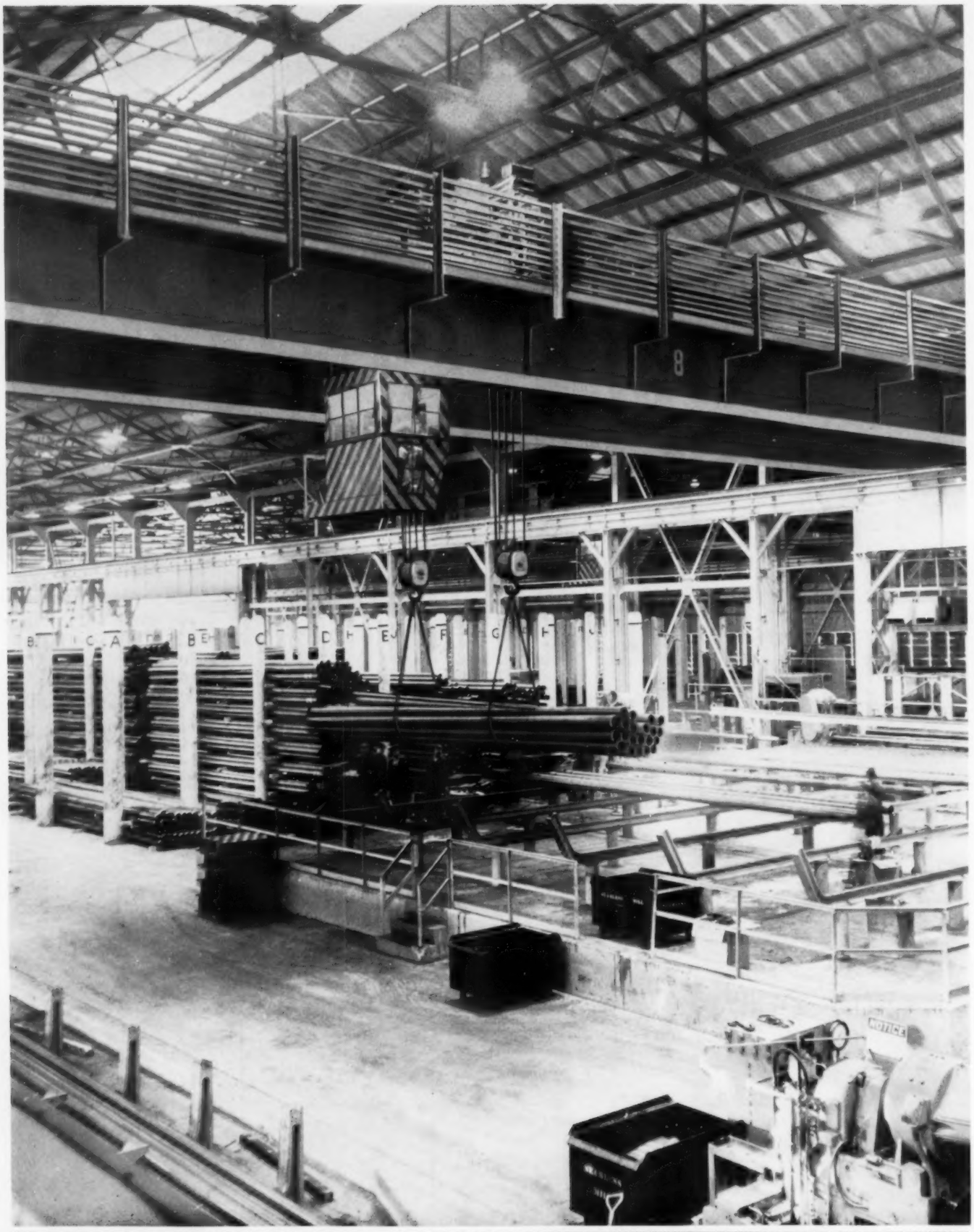

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MODERN ALL-WELDED STEEL MILL CRANES

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WICKLIFFE, OHIO

Crops *and* Shorts

THIS year marks the centennial of the steel industry. The pneumatic process of steelmaking, developed simultaneously by Henry Bessemer in England and William Kelly in the United States one hundred years ago, opened the way for rapid, economical production of large quantities of steel. The steel industry has come a long way since that time.

This year also marks the golden anniversary of the Association of Iron and Steel Engineers, which has also come a long way since it was started 50 years ago by 28 pioneer steel plant electrical men.

AISE is proud to have had a part in bringing the steel industry to its present strength and efficiency. We look forward to our part in the developments that are to come.

▲

THE oxygen converter process for steelmaking continues to gain ground in the United States. Acme Steel Company has announced plans to install two oxygen converters which will receive hot metal from two hot blast cupolas. Kaiser Steel Corporation has three oxygen converters in its expansion program which will bring its steel capacity up to about 3,000,000 tons per year. Jones and Laughlin Steel Corporation's construction program at Aliquippa includes two oxygen converters.

A number of other producers are looking carefully at the process and more installations may be expected.

▲

IRON ore imports in 1956 set a record of about 34,000,000 tons, almost 30 per cent greater than the record set in 1955. More than 45 per cent of 1956 imports were from Canadian sources and nearly 47 per cent from Latin American countries, principally Venezuela and Peru.

▲

GRANITE City Steel Company, which obtains its iron ore from Iron Mountain in Missouri and from the Lake fields, recently received 5000 tons of Peruvian ore for trial in its blast furnaces. The Peruvian ore, a dense magnetite with 59 per cent iron content, was shipped to Mobile, Alabama, where it was loaded into railroad hopper cars.

▲

WITH the public not tearing down doors to buy the auto industry's expensive, misshapen monsters, lack of demand for steel sheet has cut the average steel operating rate to about 90 per cent. Some plants still hold 100 per cent, while others would be glad to have 70 per cent, depending on the respective product mixes. Demand is still heavy for plate and structurals—both lower priced items that fail to put the sparkle in steelmakers' eyes. Tubular products and wire are also holding up well.

Despite the gloom in some quarters, we're still making a lot of steel, and when the year is over, we'll find it looks pretty good. After all, business prophets tell what's going to happen—profits tell what happened.

▲

IN spite of the fact that some steel companies' plans for new construction are not being pushed hard right now, the grapevine has it that a new integrated plant on the West coast is closer than ever before.

▲

THE Value Line investment survey visualizes normal steel demand in the United States three to five years hence at about 125,000,000 tons per year.

▲

A COMPARISON of the controversial Federal budget with that of 1954 shows a defense costing $3,600,000,000 less but non-security spending up by $7,600,000,000. Here is a net increase of $4,000,000,000 in the many continually expanding programs where the government is doing for the people things which they could and should do for themselves—things which the people themselves do not want but which are pushed on them by minority pressure groups and by bureaucrats intent upon expanding their own scope of activity.

Unfortunately, our Federal government, the world's largest, most complex enterprise, gives no incentive to reducing personnel, lowering expenses, returning unexpended funds—in short, to good management.

▲

IT'S a trusting wife indeed who thinks her husband was out with a cosmetic salesman when she finds a lipstick in the car.

▲

PAYROLL costs in the steel industry of the United States are now averaging more than $2.85 per hour plus about 29 cents per hour for pensions, social security and insurance. Total employment is estimated at more than 677,000.

▲

INDIANA has a new "right-to-work" law, the first to be adopted by a major industrial state. Opposition was bitter, with threats of violence.

Other states have similar laws under consideration. In several instances, "right-to-work" amendments to fair employment practice bills have been defeated. Isn't it odd that legislators who decry discrimination stemming from race, creed or color close their minds to discrimination against individuals who don't want to join a union?

The strong-arm tactics employed by unions and their disdain for the public and government clearly indicate that regulation is badly needed. Maybe further hearings of the U. S. Senate Committee will convince our lawmakers.

ANY WAY YOU LOOK AT THEM

BUILT TO MEET AISE-NEMA STANDARDS

√ Mounting Dimensions
√ Wheel Diameters
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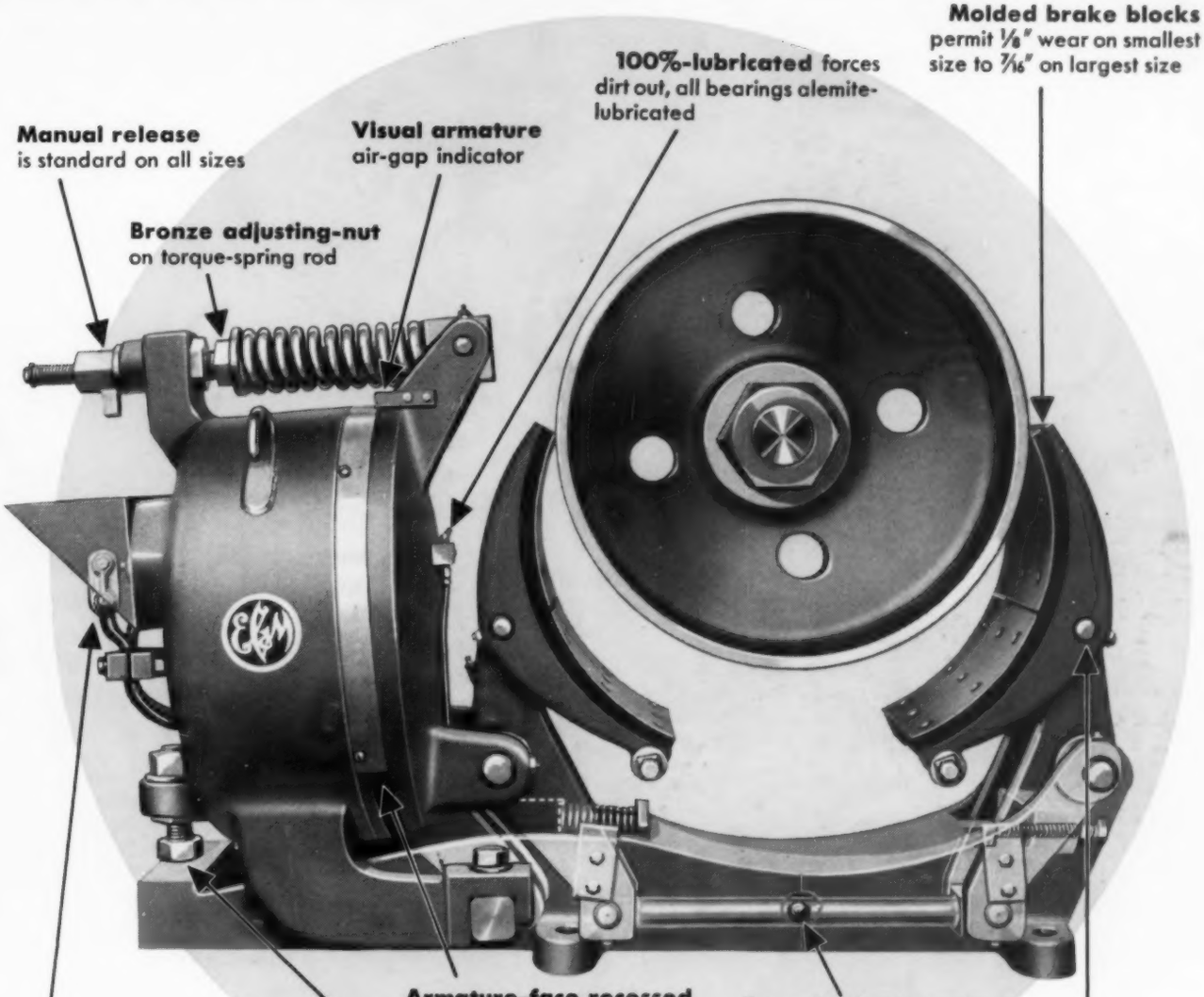
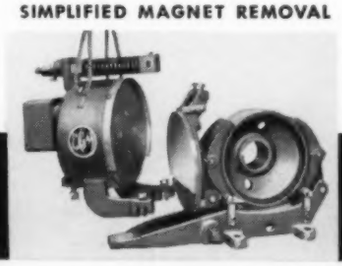
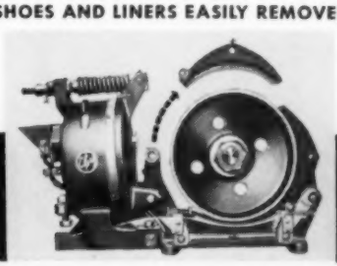
EC&M "WB" BRAKES RATE #1


Molded brake blocks permit 1/8" wear on smallest size to 7/16" on largest size
100%-lubricated forces dirt out, all bearings alemite-lubricated
Manual release is standard on all sizes
Visual armature air-gap indicator
Bronze adjusting-nut on torque-spring rod
Armature-face recessed at bottom allows dust to fall free—prevents clogging
Connecting lever remains **below the brake wheel**
Solderless connectors under protective shield. Conduit connection box is optional
Single adjustment for brake lining wear. Adjusting-nut screws into stainless steel, threaded bushing in magnet-case
Fixed bearing-pins locked with stainless steel set-screws reduce number of lubrication points

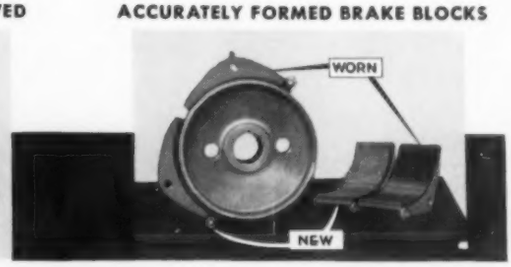
SIMPLIFIED MAGNET REMOVAL



SHOES AND LINERS EASILY REMOVED



ACCURATELY FORMED BRAKE BLOCKS



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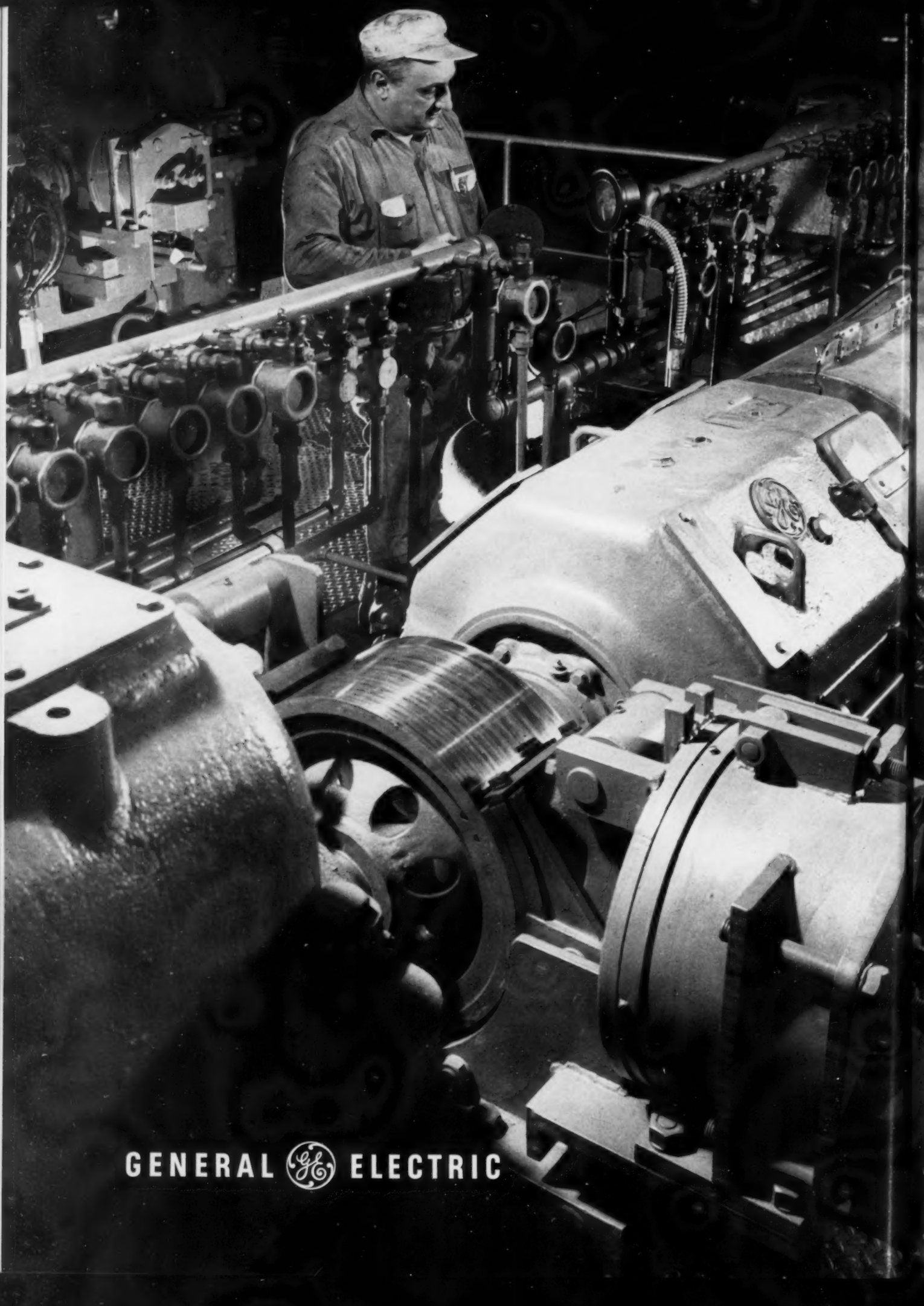
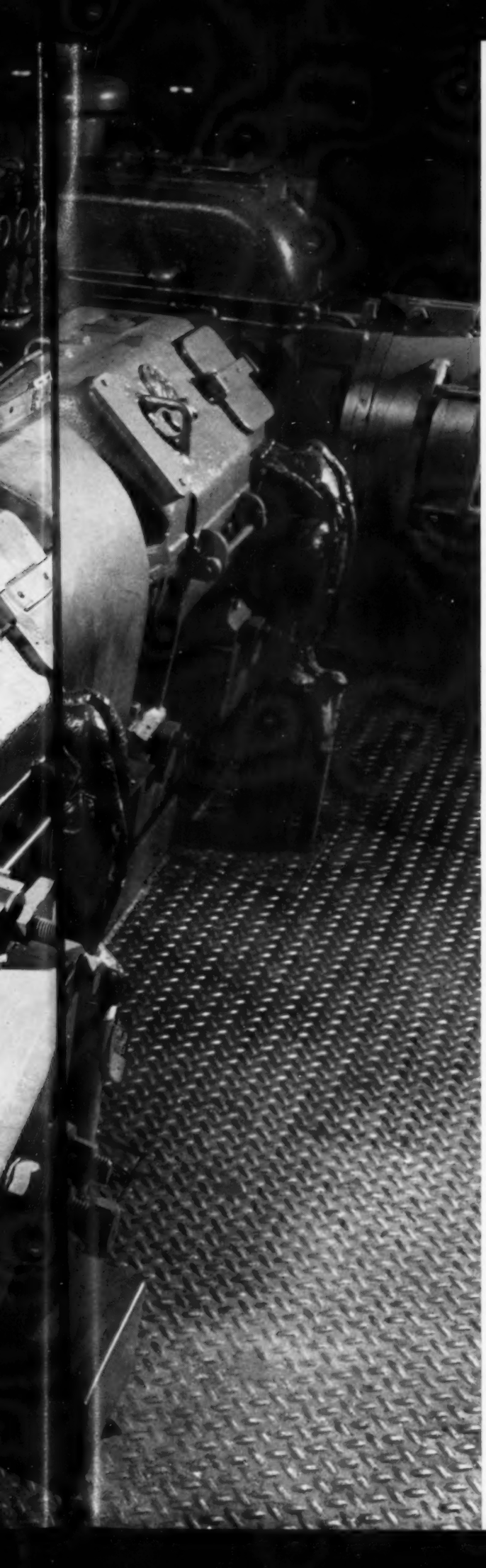

GENERAL ELECTRIC



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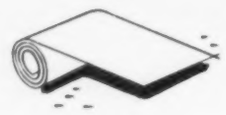
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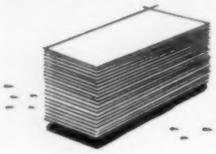
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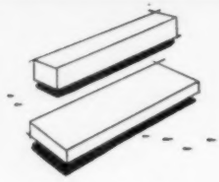
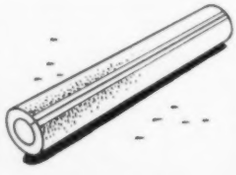

SLABS & BILLETS

STRUCTURALS

BAR STOCK

WIRE ROD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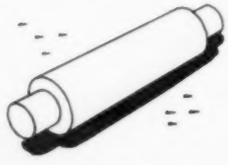
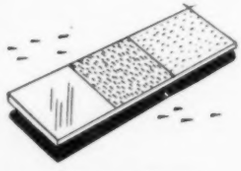

MILL ROLL ETCH

MOLD CONDITIONING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- Reduces manhour needs
- Requires only 1/3 to 1/2 the floor space
- Gives improved surface for cold working and cold forming
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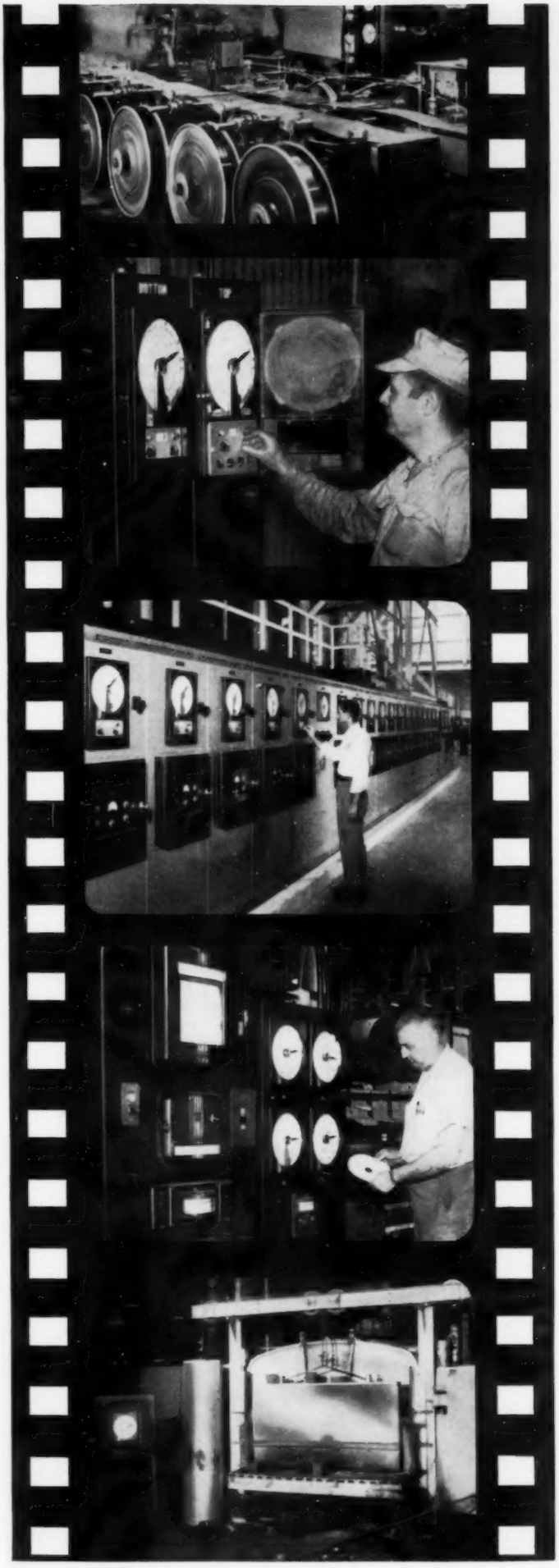

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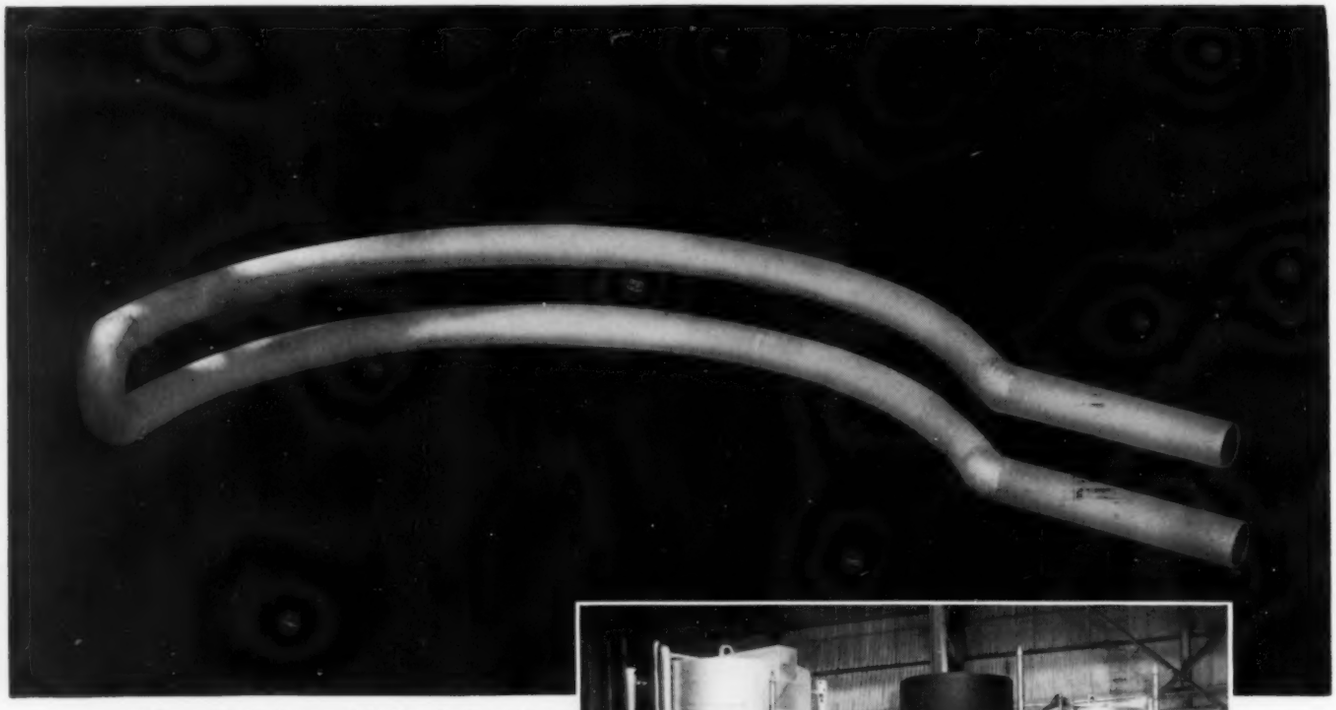
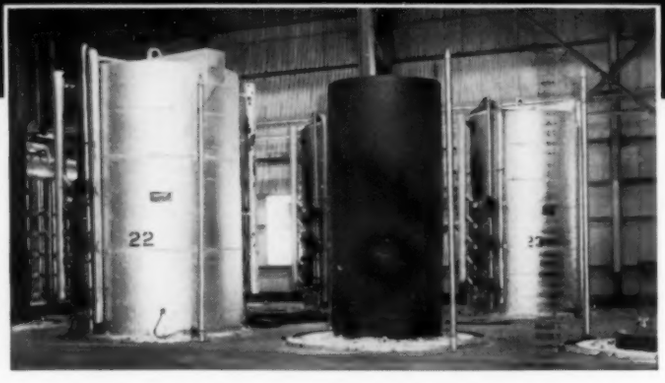


"Curved-Tube" assembly for single-stack annealer, centrifugally cast of Thermalloy high-heat-resistant alloy.



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Patent Reviews

by
MELVIN NORD
Patent Attorney,
Detroit, Mich.

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period December 4, 1956 through December 25, 1956. . . .

SEPARATION OF IRON ORE FINES

▲ U. S. 2,772,776, issued Dec. 4, 1956 to Thomas L. Myron and assigned to United States Steel Corp., provides an apparatus for separating fines from iron ores to be charged to a blast furnace.

As shown in Figures 1 and 2, the apparatus consists of a mixing conveyor 10 and a series of separating conveyors 12. The conveyors each include an endless belt 13 and a pair of pulleys 14 and 15 around which the belt travels, one of which is power driven. The upper flights of successive conveyors are spaced vertically a minimum distance of about two feet. The conveyor speed is 250 to 500 fpm.

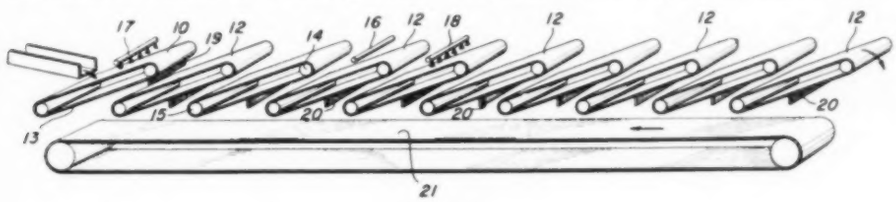

Figure 1

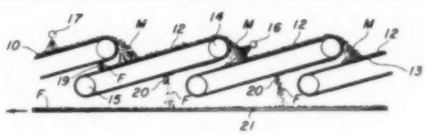

Figure 2

Granular ore feed M is introduced to the upper flight of the mixing conveyor 10 to form a continuous bed about $^1/_2$ in. deep. The material discharges from the mixing conveyor 10 to the upper flight of the first separating conveyor 12 and then to each succeeding separating conveyor. When discharging from one conveyor to the next, the material has a trajectory and a free fall of at least two ft. This action tends to throw coarser particles further out than fines and thus to produce a stratified bed on each separating conveyor in which the fines are laid down adjacent to the belt surfaces. The tendency of the material to stratify can be enhanced by directing air jets downward and backward against the falling material, through air manifolds 16. The tendency to stratify is also enhanced by repeated discharging from one conveyor to another.

There should be sufficient water in the bed to wet the rubber belts 13 and the ore M. If necessary, water can be sprayed on, through sprays 17 and 18. Wet fines F in contact with the belt surfaces tend to cling to it and travel to the lower flight of the conveyor, rather than to discharge to the next conveyor. A scraper 19 is supported in contact with the lower flight of the belt of the mixing conveyor, directing these fines to the first separating conveyor. However, each of the separating conveyors has a scraper 20 which discharges fines to a fine-collecting conveyor 21. The material which discharges from the last separating conveyor is predominantly a coarse product.

AUTOMATIC CENTERING APPARATUS

▲ U. S. 2,772,879, issued Dec. 4, 1956 to Edwin T. Lorig and assigned to United States Steel Corp., describes automatic centering apparatus for strip material.

One form of the invention is shown in Figure 3. The numeral 1 indicates a roll over which strip S passes. The roll is made of a metal core 2 mounted on a shaft 3 and covered with a shell of rubber 5

having a radial slit 6 around its periphery on the transverse center of the roll. A number of inclined slits 8 and 10 are also provided on opposite sides of the slit 6 to form a number of closely spaced laminations 11 and 12. The slits are made with a thin razor-edged tool which does not remove any substantial amount of material, thus avoiding the formation of grooves. The center portion of the roll is of greater diameter than the ends of the roll, thus providing shoulders 16.

When the roll is rotating at high speeds under no external pressure, centrifugal force will tend to move

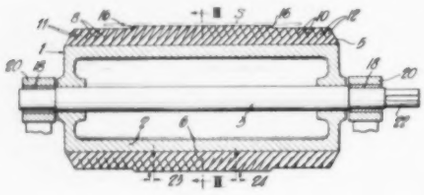

Figure 3

the separate sections or flexible laminations of the roll outwardly, and when the strip S passes over the roll surface, it will move the roll surface inward toward the axes of the roll and also toward the transverse center of the roll. If the strip is off-center, the section of the roll having the greatest total area in contact with the strip and the greatest total pressure will force the strip toward the center.

The patent also describes several other modifications of the invention.

METHOD FOR ELECTROLYTICALLY POINTING WIRE

▲ U. S. 2,773,024, issued Dec. 4, 1956 to Robert W. Gurry and assigned to United States Steel Corp., describes a method and apparatus for electrolytically pointing wires.

As shown in Figures 4, 5 and 6, the apparatus consists of a vessel 10 which contains an electrolyte and a copper gauze cathode 12. A number of J-shaped glass tubes 13 are supported in the vessel, the lower ends being immersed in the electrolyte.

Wires W, for example, of hard drawn high-carbon steel or stainless steel, are inserted in the tubes 13, a different wire in each tube. The wires are pushed through the tubes

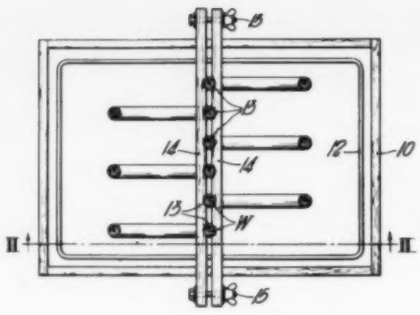

Figure 4

from above, and a sufficient length is left protruding above the top to enable an electrical connection to be made to it. The other ends of the wires terminate at the top of the shorter arms of the glass tubes. A centering constriction 16 is provided in the glass tube.

The configuration of the point can be controlled by selection of a tube having the proper diameter, and by adjusting the temperature of the electrolyte. The J-shaped tubes have the advantage that a thin protective layer of spent electrolyte adjacent to the wires, being more dense than the rest of the electrolyte, flows down over the wire away from the tip and protects the wire from electrolytic attack.

RECOVERY OF SULPHURIC ACID AND IRON OXIDE FROM SPENT PICKLE LIQUOR

▲ U. S. 2,773,743, issued Dec. 11, 1956 to Walter Fackert, describes a method of recovering sulphuric and iron oxide from waste pickle liquor.

The waste liquor is cooled to room temperature, precipitating out iron sulphate. The iron sulphate is brought into contact with steam at about 75 C in an air-free chamber, in the presence of an oxidizing agent such as nitric acid. This converts the iron sulphate directly to absorbable sulphuric acid and iron oxide. The reactions are:

$$FeSO_4 + H_2O \rightarrow FeO + H_2SO_4$$

$$2FeSO_4 + H_2O \rightarrow Fe_2O_3 + SO_2 + H_2SO_4$$

$$2FeSO_4 + H_2O + HNO_3 \rightarrow Fe_2O_3 + 2H_2SO_4 + HNO_2$$

The nitrous acid is vaporized and oxidized with air. Thus, the nitric acid is regenerated and recycled for further use.

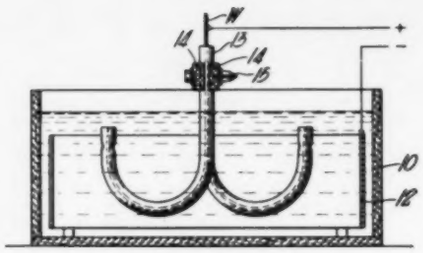

Figure 5

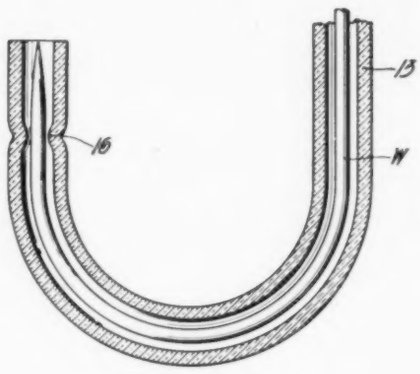

Figure 6

LADLE MAINTENANCE APPARATUS

▲ U. S. 2,774,123, issued Dec. 18, 1956 to June H. Reighart, provides an apparatus for maintenance of ladles.

Since the bottom nozzles of ladles burn out and must be replaced after each heat is poured, and since the ladle is extremely hot from the previous heat, considerable time is required in order to allow the ladle to cool to an extent sufficient to allow a man to enter the ladle and replace the nozzle. In general, nozzles are tapered inwardly towards their bottoms and are cemented in the ladle, and for this reason cannot satisfactorily be replaced from outside the ladle. Besides being a disagreeable job, it takes $2^1/_2$ to 3 hrs of cooling before the man can enter the ladle, and after his work is done, it takes another 1 to $1^1/_2$ hr for the cement to dry around the new nozzle.

These problems are overcome by means of the removable ladle insert provided in the present invention. As shown in Figure 7, a heat-resisting insert or liner is provided, consisting of steel bucket-shaped outer and inner shells 20 and 21 with insulating material 22 between them. This liner can be inserted within the ladle, with a small clearance around the circumference of the insert, providing air circulation around the

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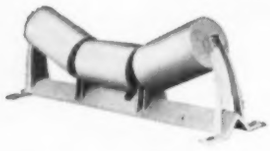
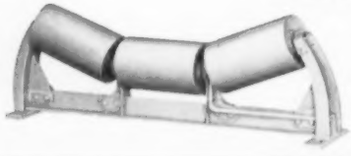
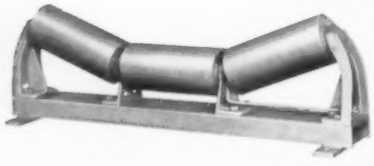
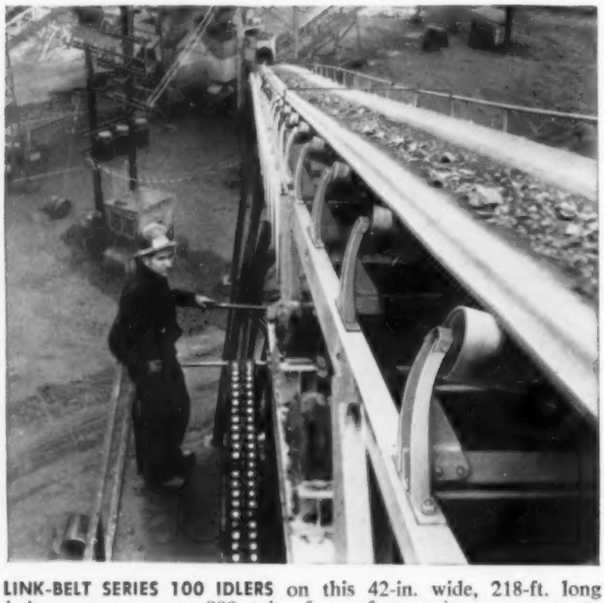
IDLER SERIES	TYPE OF IDLER DUTY	TYPICAL APPLICATIONS
NEW 50 	General duty conveyor • for maximum loads of 100 lbs. per cubic foot • for moderate lump sizes	Designed for conveyors carrying medium loads or for installations requiring intermittent operation.
100 	"Round-the-clock work horse" • handles all but the heaviest and coarsest materials	Coal, coke, sand, gravel, iron ores, sinter, taconite, potash.
200 	Rugged heavyweight • for continuous service • carries the heaviest and coarsest materials	Heavy ores, such as iron, copper, etc. . . . on conveyors employing high-capacity belts.



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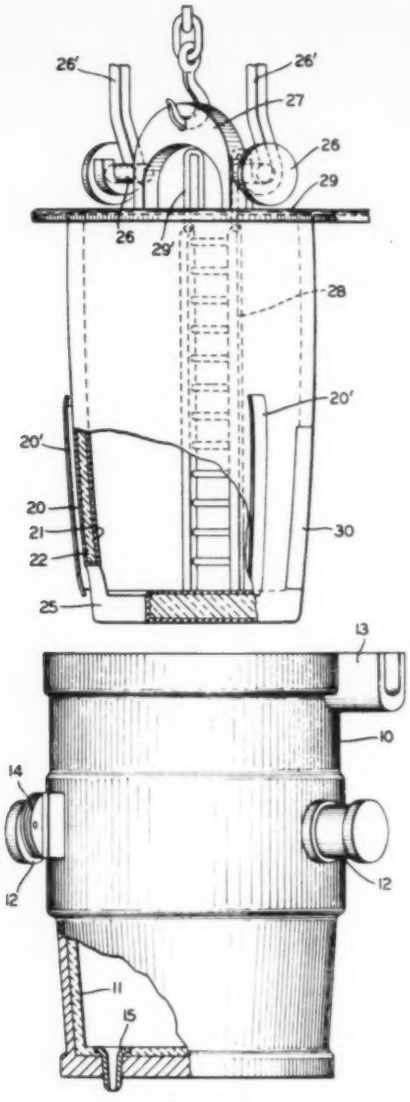


Figure 7

insert. Spacer guides 20′ center the insert in the ladle.

An opening 25 is cut out from the insert above the nozzle 15. When it is desired to replace a nozzle, the insert is lowered into the ladle. A man can then descend the ladder 28 to do the required work on the nozzle. An additional entry means to the insert is provided by means of a door 30 which swings on hinges, so that tools and materials may be placed in the insert before it is placed in the hot empty ladle.

INDUCTIVE STIRRING DEVICE FOR A METALLURGICAL FURNACE

▲ U. S. 2,744,803, issued Dec. 18, 1956 to Ludwig Dreyfus and assigned to Allmanna Svenska Elektriska Aktiebolaget, describes an inductive stirring device for an arc furnace, an open hearth furnace, or a hot metal mixer. There is no water-cooled winding below the bottom of the furnace, so that the risk of explosions arising from molten metal coming into contact with water in the winding, if the furnace lining should fracture, is eliminated.

As shown in Figures 8 and 9, the numeral 1 designates the lining of the furnace bottom, 2 the non-magnetic shell and 3 the molten metal charge. 4 designates the magnets, which are rotated by shafts 5. 6 are the magnet windings and 7 the pole shoes.

Rotation of the pole axes through 90 degrees alters the direction of the magnetic lines of force as shown in the two figures.

The resulting eddy currents stir the charge, thereby preventing excessive overheating of the charge near the arcs of an arc furnace, and facilitating deslagging of the charge.

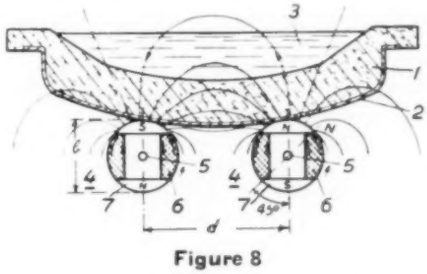
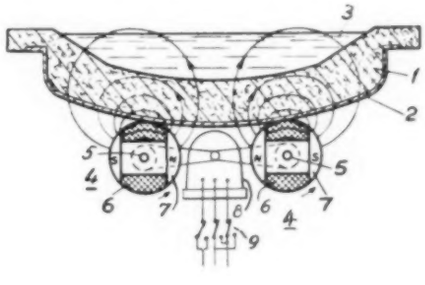


Figure 8

Figure 9



OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,772,612	12/4/56	Sheet piling mechanisms	United States Steel Corp.
2,772,777	12/4/56	Magnetic separation of ores	Augustin L. J. Queneau
2,772,918	12/4/56	Dumping tractor-trailer vehicle	United States Steel Corp.
2,772,958	12/4/56	Indurating process	Erie Mining Co.
2,772,959 & 2,772,961	12/4/56	Production of ferro-nickel or ferro-cobalt	Quebec Metallurgical Industries Ltd.
2,772,960	12/4/56	Slag car for open hearth furnaces	Armco Steel Corp.
2,772,992	12/4/56	Production of stainless steel	Allegheny Ludlum Steel Corp.
2,773,112	12/4/56	Arrangement for positioning electrodes of an electric arc furnace	Licentia Patent-Verwaltungs-G.m.b.H.
2,773,610	12/11/56	Program control system for charging blast furnaces	John Mohr & Sons
2,773,682	12/11/56	Burner support for open hearth furnaces	United States Steel Corp.
2,773,761	12/11/56	Ferrous chrome alloy	Calumet Steel Casting Corp.
2,774,263	12/18/56	Rolling mill	Aktiebolaget Svenska Kullagerfabriken
2,774,368	12/18/56	Blast furnace wind distribution control	Askania Regulator Co.
2,774,459	12/18/56	Rack for cooling fresh galvanized pipe	Oscar R. Olson
2,774,593	12/18/56	Apparatus for guiding strip material	Armco Steel Corp.
2,774,662	12/18/56	Melting sponge iron in a fluidized bed	Bethlehem Steel Co.
2,775,301	12/25/56	Split die members	Allegheny Ludlum Stee Corp.
2,775,441	12/25/56	Cooling cover for annealing furnaces	Bethlehem Steel Co.
2,775,508	12/25/56	Treatment of waste pickle liquor, for recovery of iron values and ammonium sulphate	Alfred M. Thomsen
2,775,518	12/25/56	Production of ferromanganese	Strategic-Udy Metallurgical & Chemica Processes Ltd.
2,775,675	12/25/56	Method of welding steel tubing	Republic Steel Corp.

CLEANING TINPLATE

▲ U. S. 2,775,535, issued Dec. 25, 1956 to William D. Poole and assigned to Bethlehem Steel Co. describes a method of cleaning and modified passivating of electrolytic triplate produced in continuous strip form which may, before treating, have on its surface objectionable products which interfere with the adherence of phenolic type baked enamels.

According to the inventor, when electrolytic tinplated strip is cleaned cathodically in a dilute alkaline solution just prior to fusing, and the strip is then passed through a fusing furnace, if the strip is given a sequential treatment of cathodic cleaning in a dilute alkaline solution and rinsed in a dilute chromic acid solution, good adherence of enamels is obtained, and surface oxidation is retarded even when the strip has been in storage for relatively long periods before enameling.

Specify... **J-M Asbestos Wick** **J-M Asbestos Rope**

Wherever you need general utility packings that are easy to handle, highly heat resistant

Throughout the iron and steel industries, the list of uses for Johns-Manville Asbestos Wick and Rope is constantly growing. These soft, resilient, heat-resisting materials are widely employed for general packing, gasketing and caulking applications.

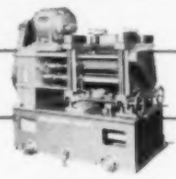
In coke ovens, both are used to caulk around the doors to prevent the escape of gases. Asbestos Rope (Style 4200) also serves as expansion joint material in the brickwork.

Only a few of the many applications for Asbestos Wick (Style 4202) can be given here. It seals hot metal in the ingot mould, around the top and between the mould and the stool. It gives protection from burning to water hoses that cool Open Hearth doors. It serves as a seal between the cope and drag on moulding flasks. It is used to wipe excess coating from wires after passing through the galvanizing bath.

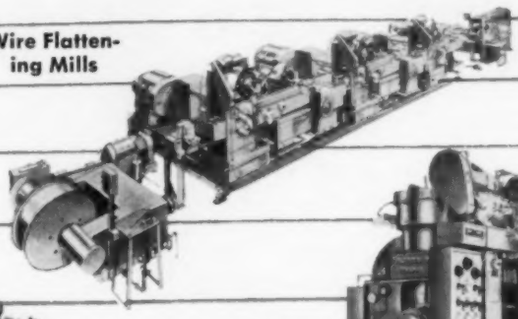
Styles 4200 and 4202 are made from pure asbestos fibre carefully controlled for quality at Johns-Manville's own mine and mill (largest in the world). Asbestos Rope is formed by twisting together two or more strands of Wick to obtain the desired thickness. For further information, call your local J-M distributor or write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

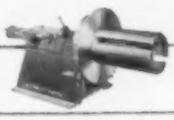
Johns-Manville PACKINGS, GASKETS and TEXTILES

JOHNS-MANVILLE JM PRODUCTS



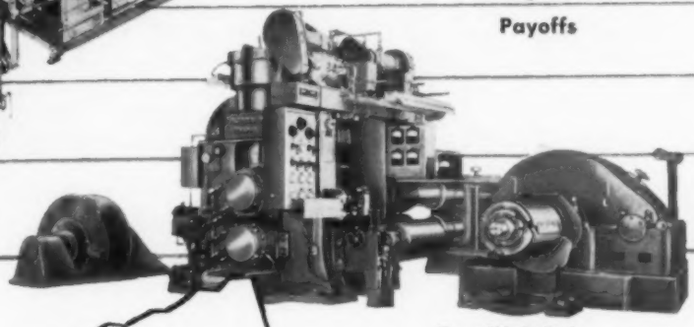
Wire Flattening Mills

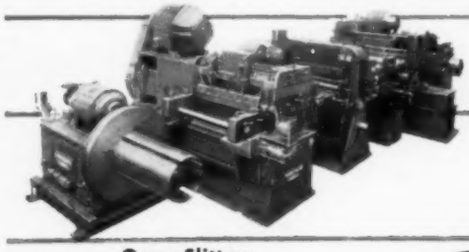




Payoffs

Coilers





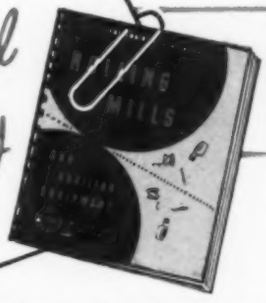
Gang Slitters

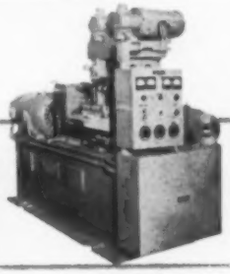
Two High Strip Rolling Mills

MEMO

Re Rolling Mill Modernization

Look Into Latest Waterbury Farrel Mill Machinery

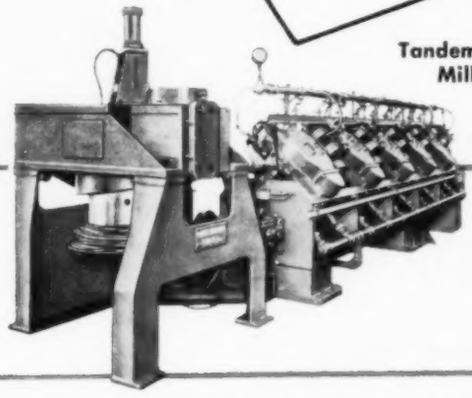




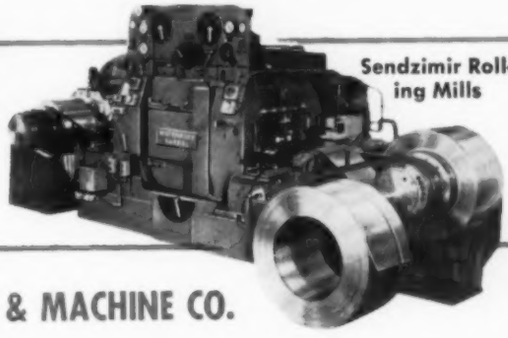
Four High Strip Rolling Mills

Coil Boxes

NEW, 48 PAGE MILL MACHINERY CATALOG. Gives a complete picture of the various types of mills and auxiliary equipment built by Waterbury Farrel. Send for your copy, today.



Tandem Rod Mills



Sendzimir Rolling Mills

ROLLING MILL EQUIPMENT

Four-High Rolling Mills
Gang Slitters
Grading Mills
Mint Mills
Sendzimir Rolling Mills
Special Rolling Mills
Two-High Rolling Mills

AUXILIARY EQUIPMENT

Coil Boxes
Coilers
Coil Lifts and Transfers
Belt Wrappers
Edgers
Handling Equipment
Payoffs
Straighteners
Winders

ROD AND TUBE MILL EQUIPMENT

Draw Benches
Tandem Rod Mills
Three-High Rod Mills
Two-High Rod Mills

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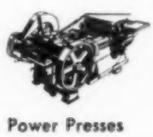
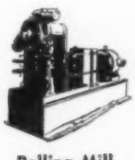
WATERBURY FARREL FOUNDED 1831

Bolt, Nut & Screw Machinery



Power Presses



Rolling Mill Machinery

Wire Mill Equipment

Sendzimir Mills & Other Special Machinery

WF-31

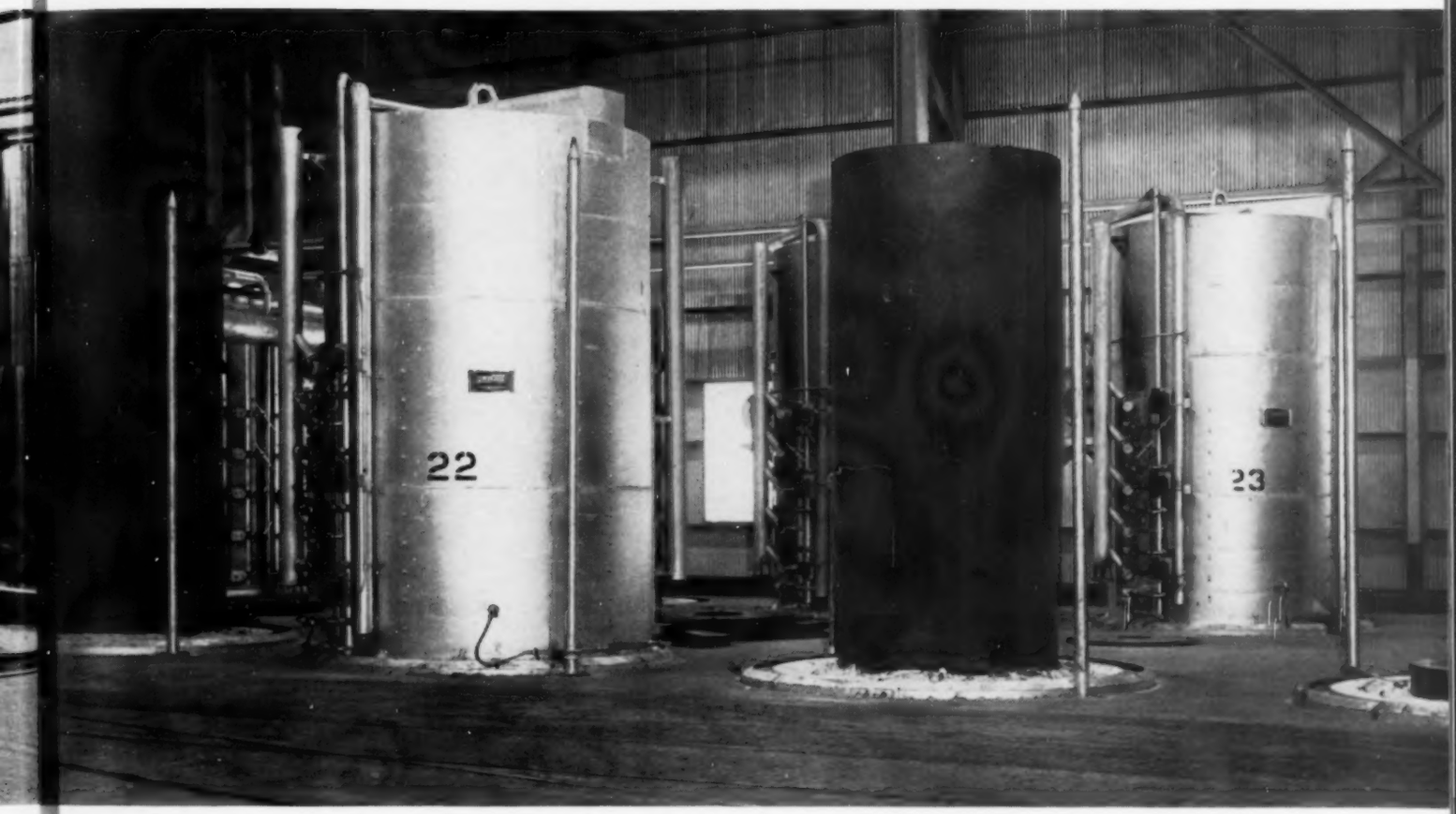
SWINDELL

Multi-Stack and Single-Stack

ANNEALING FURNACES

- for better operating efficiency
- and better customer service—

EQUIP WITH BOTH!



Here's why:

When you equip with *both* Swindell Multi- and Single-Stack Annealing Furnaces in the same shop, you profit!

- You render more effective service to your customers because better equipment flexibility enables you to handle efficiently a greater variety of jobs.
- Additional efficiency is gained because operating techniques and procedures are similar for both types.
- You save in parts inventory and maintenance because burners, load bases, inner covers and other major components are interchangeable throughout.

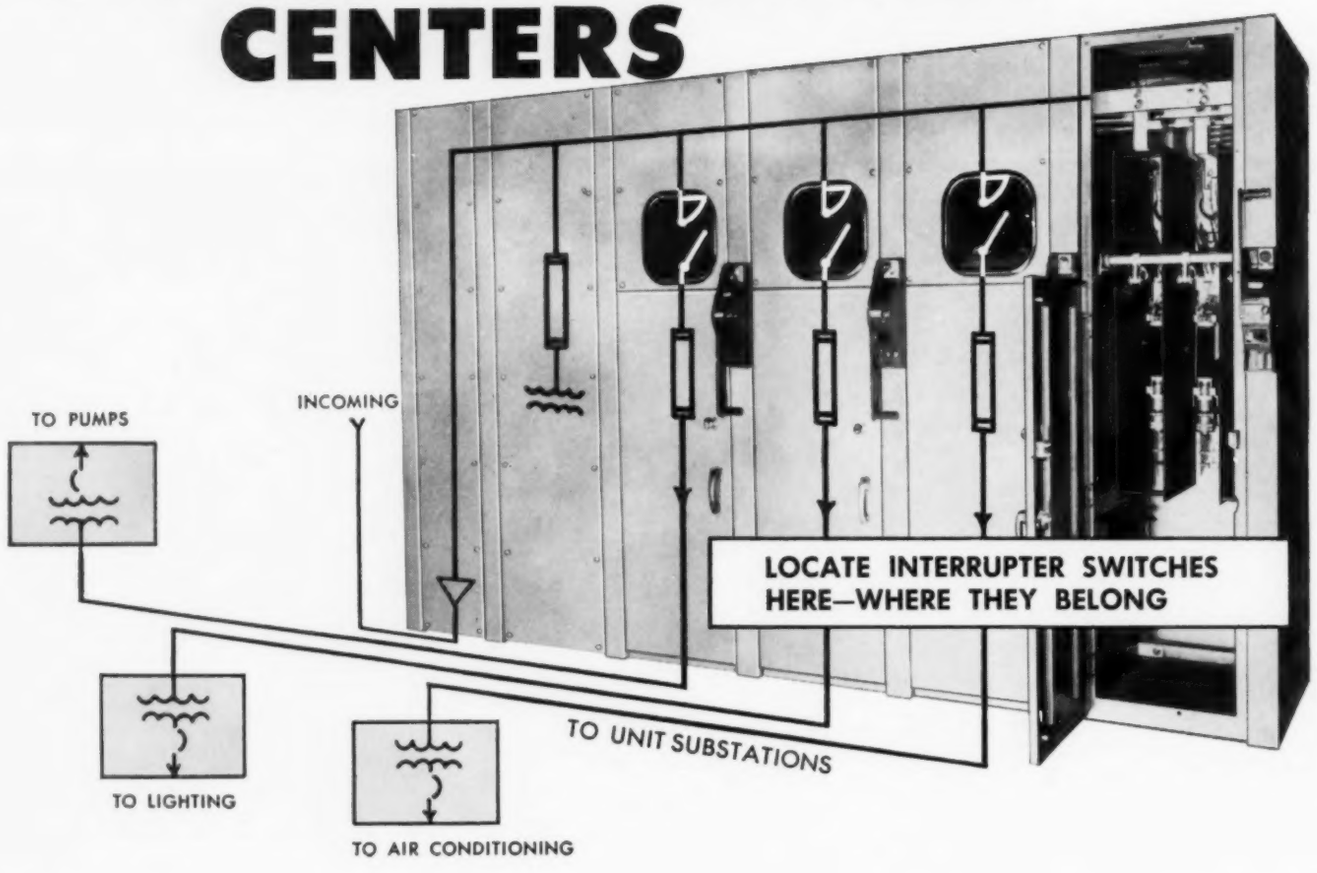
A SWINDELL-DRESSLER engineer will be pleased to provide further information!

SWINDELL-DRESSLER Corporation

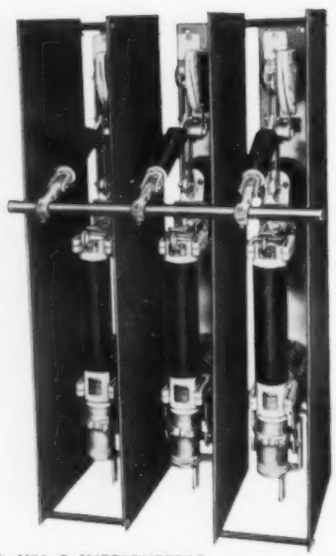
DESIGNERS AND BUILDERS OF MODERN INDUSTRIAL FURNACES

PITTSBURGH 30, PA.

R&IE POWER SWITCHING CENTERS



✔ Cost Less ✔ Save Space ✔ Easier to Maintain



FUSED HPL-C INTERRUPTERS
Ratings—up to 14.4 Kv (110 BIL)
600 Amp. (40,000 Mom.), 1200 Amp. (60,000 Mom.)

Specify TOG-L SNAP operating mechanism for closing- in fault protection.

PSC HIGH VOLTAGE CUBICLES, standard design, indoor or outdoor, offer both efficiency and economy.

SAVE FIRST COST—Standardized, low-cost PSC cubicles with HPL-C fused interrupters, feature sectional main bus—providing compact flexibility. PSC means lower cost per feeder than scattered locations of switches in unit substations.

SAVE SPACE—With dry type load center transformers, PSC can save many square feet of floor space at the unit substation location. They also may be mounted overhead, saving additional floor space.

EASIER TO MAINTAIN—Easily operated, accessible for inspection. Can be handled with any maintenance crew.

PROTECT SYSTEM—Against faults in cables as well as transformers.

ADD FEEDERS any time—up to 1200 Amp. total load.

Ask your I-T-E Representative to show you the many PSC economies. Data available.

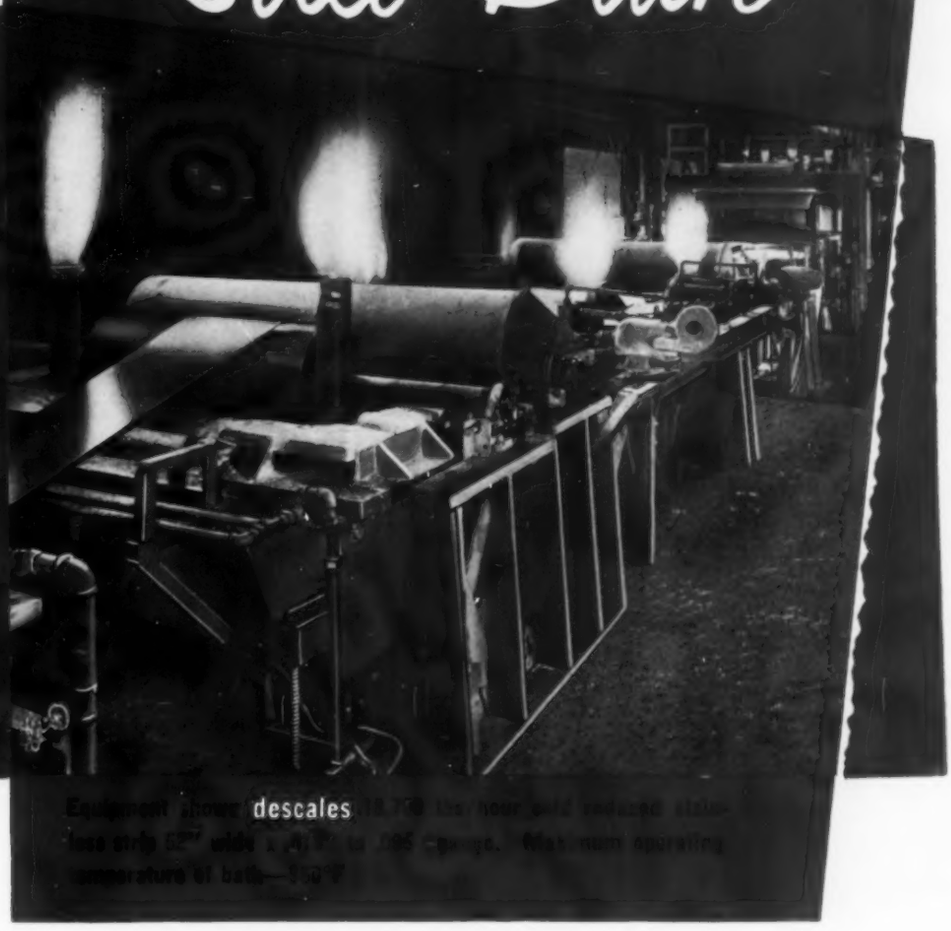
R&IE

R&IE EQUIPMENT DIVISION
I-T-E CIRCUIT BREAKER CO.
GREENSBURG, PA.

PSC - 5

DREVER Salt Bath

for CONTINUOUSLY DESCALING STAINLESS STRIP



descales

The above 35′-0″ long Drever Continuous Descaling Bath will descale 18,700 lbs/hour when strip enters bath at bath temperature. Entering strip temperature is controlled by regulation of quenching temperature after strip is discharged from a catenary annealing furnace.

Drever descaling baths are heated by gas-fired immersion tubes with proportioning automatic temperature control.

Other baths are supplied for continuous or batch operation for strip, plate, wire, tubing and other ferrous or non-ferrous products.

Write for full information...

DREVER COMPANY

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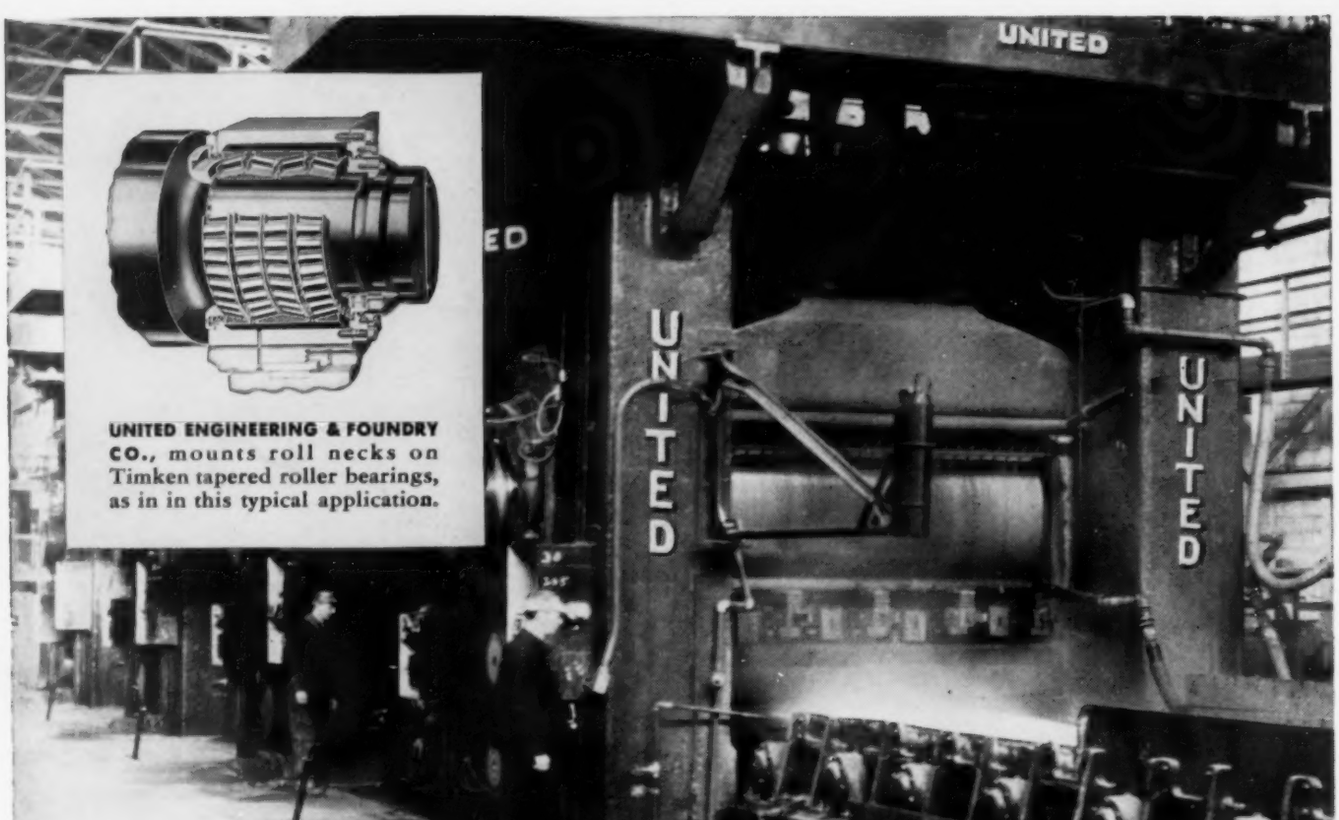


UNITED ENGINEERING & FOUNDRY CO., mounts roll necks on Timken tapered roller bearings, as in in this typical application.

Another record! TIMKEN® bearings on this plate mill have rolled 9 million tons of steel

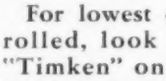
THIS 100" 4-stand continuous plate mill — built by United Engineering — went into service at U. S. Steel's Homestead Works in 1936. Some of the Timken® tapered roller bearings on work rolls and back-up rolls have now rolled 9 million tons of steel—all 31 Timken bearings in the mill have rolled an average 5 million tons.

One big reason for this record is the fact that Timken bearings practically eliminate friction. They're geometrically designed and precision-made for true rolling motion. Timken bearings offer low frictional resistance. Higher rolling speeds are possible. Acceleration is easier. There's less skidding and scuffing between rolls. Less repair and maintenance.

By holding rolls rigid, Timken bearings help insure "on-gauge" operation, reduce scrap loss. And by holding shafts and housings concentric, Timken bearings make closures more effective, reduce lubricant leakage. Cut lubricant cost. Grease-lubricated Timken bearings require no tubes, pipes or reservoirs—cut lubrication system maintenance. No extra thrust devices are needed—the tapered construction of Timken bearings lets them take radial and thrust loads. Chuck mountings are more compact. Mill design is simplified.

Tonnage records indicate that the long life of Timken bearings keeps bearing cost per ton of steel rolled to a minimum. And prolonged roll life is assured because Timken bearings provide maximum roll neck strength, less wear. Mills using balanced proportion Timken roll neck bearings increase roll neck strength up to 60%—load ratings up to 40%. The balanced proportion design permits large diameter roll necks without increasing bearing O.D.—maximum capacity in less space.

For lowest cost per ton of steel rolled, look for the trade-mark "Timken" on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ont. Cable: "TIMROSCO".



This symbol on a product means its bearings are the best.

TIMKEN *TAPERED ROLLER BEARINGS ROLL THE LOAD*

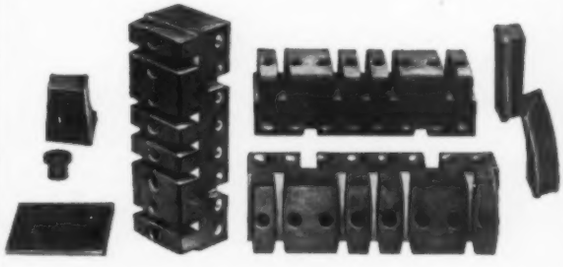
TRADE-MARK REG. U. S. PAT. OFF.

B&W Silicon Carbide Refractories for metal-working furnaces

To meet the specialized requirements of the primary metals industry, B&W manufactures Silicon Carbide Refractories in a variety of shapes and sizes. These durable refractories are produced in B&W's Augusta, Ga., works to the same rigid quality control standards used in making all B&W Refractories. See your local B&W Refractories Engineer for further information.

B&W Silicon Carbide Rolls

B&W Silicon Carbide Recuperator Tubes



B&W Silicon Carbide Special Shapes

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REFRACTORIES DIVISION
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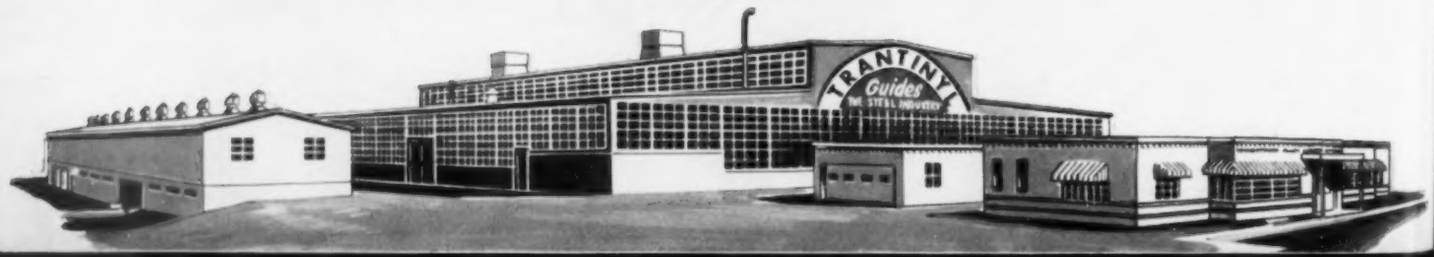
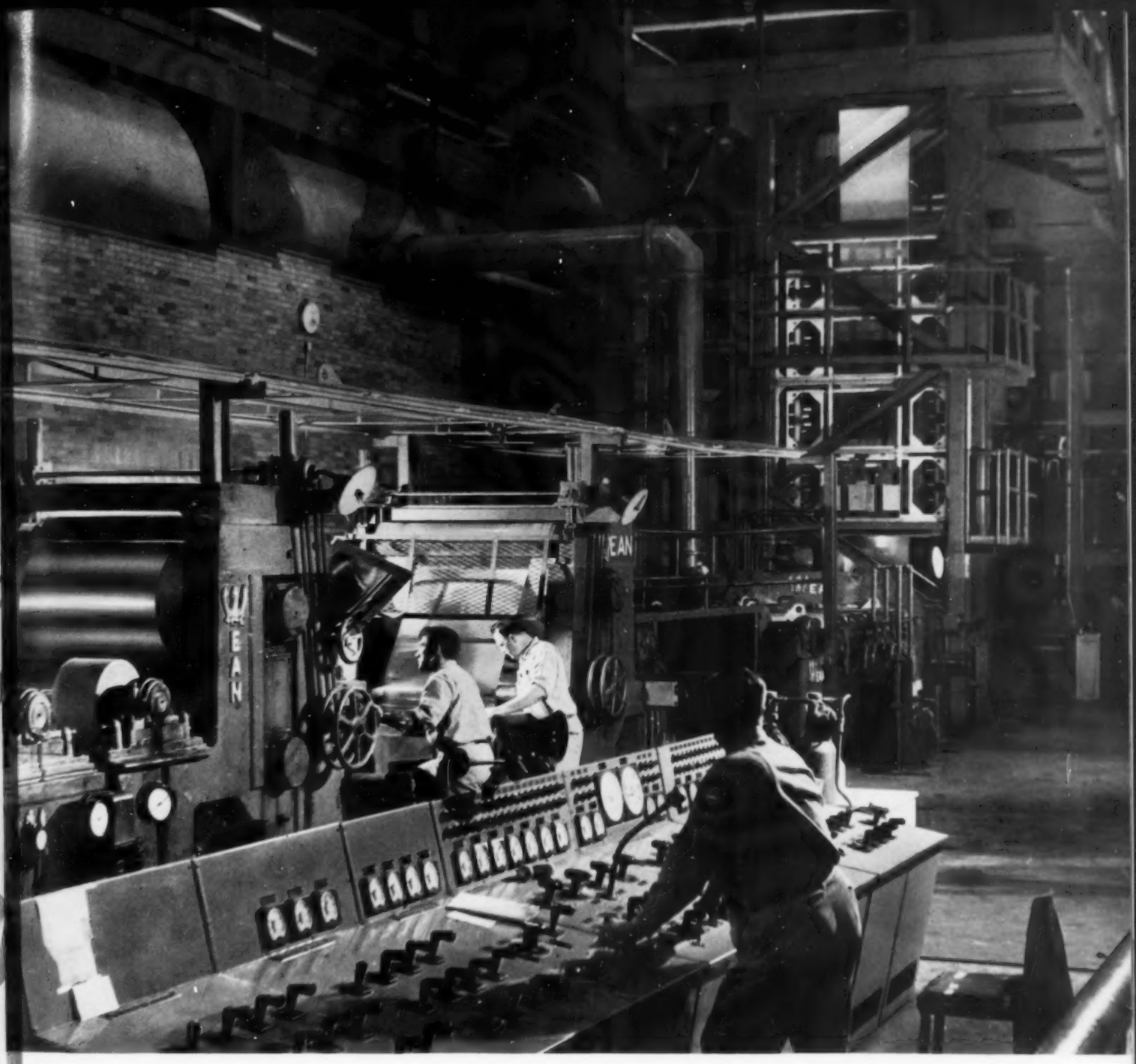
TRANTINYL

guides the steel industry



YOUNGSTOWN ALLOY CASTING CORP., • YOUNGSTOWN,

ROLLING MILLS: bar, hoop, strip, shape mill guides, and rollers. SEAMLESS TUBE MILLS: guide shoes, rolling mill plugs and rolls, piercer points, etc. ELECTRIC WELD TUBE MILL: forming rolls, planishing rolls, tool holders, etc. • STRAIGHTENING MACHINE GUIDES • HEAT RESISTING CASTINGS



More tin plate . . . mirror finish, precise alloy

Westinghouse line drive and control equipment for exacting, high-speed reflow methods helps your electrolytic tinning lines produce more salable tin plate . . . faster.

Here's how you can give your tin plate a competitive edge ——————→

YOU CAN BE SURE...IF IT'S Westinghouse

With Westinghouse radio-frequency equipment . . .

Smooth, lustrous tin plate at speeds of 2100 fpm, and beyond

Westinghouse equipment for tin-plate reflow operations helps you produce the delicate alloy balance necessary to form tin cans easier, maintain high production rates.

Westinghouse radio-frequency induction heating equipment for high-speed lines . . . both horizontal and vertical acid type . . . keeps coating thickness precise and constant by automatically adjusting plating current in proportion to line speed. Electromagnetic induction, transferring power to the strip without physical contact, melts the tin and creates a bright, nonporous surface.

This process works so fast that it produces an actual flow line on the moving strip. A photoelectric scanner continuously scans the flow line and uses it to maintain heating at the precise, desired level. There's no overheating or underheating . . . the electric equipment is capable of maintaining speeds of 2100 fpm and beyond. You save valuable tin, reduce menders and boost output of prime tin plate. Production scheduling is simplified because photoelectric scanner handles most changes in gauge and speed without adjustment.

How Line Control Operates

Magamp* magnetic amplifier regulators (VR) control voltage of the entry, main and delivery generators assuring fast, even acceleration and deceleration and minimum loop variation during steady operation. Loop regulators act as verniers in controlling generator voltages.

Magamp current regulator (CR) for booster and Magamp counter emf regulator (CEMFR) for motor work together to maintain regulated tension by the pay-off reels (POR) and winding reels (WR). Inertia compensation (IC), proportional to accelerating loads and stall tension signals, is introduced through the (CR) circuits.

Photo-thyratron loop regulators (LR) provide modulated control of storage loops for smooth operation.

Electronic regulators control top and bottom plating current to deposit proper tin coating on each side at all line speeds.

Machine characteristics are selected for optimum drive performance. Entry section pinch roll (PR), master bridle roll (MBR), and drag bridle No. 2 (DB-2), the pace setters of their respective line sections, are shunt-wound for flat speed-load characteristics. Tank drives (T) have high drooping characteristics which result in their developing only the power required to overcome their friction losses and inertia loads. Reel motors have overload capacities suitable for accelerating the large coils now used in most mills.

*Trade-Mark.

YOU CAN BE SURE...IF IT'S

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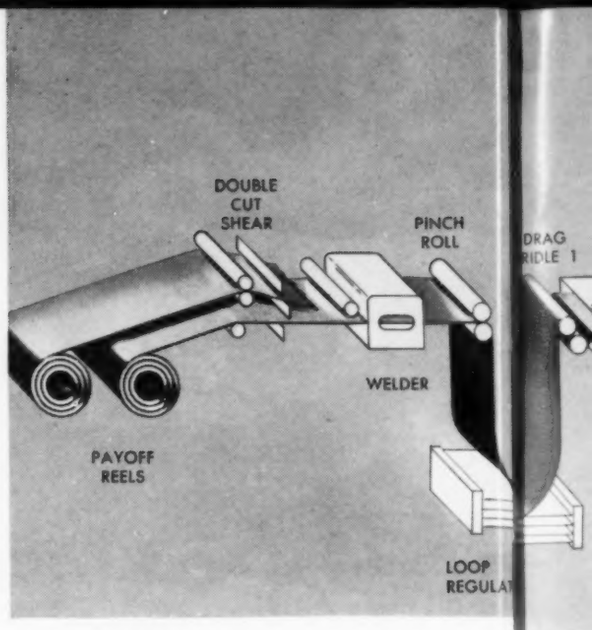
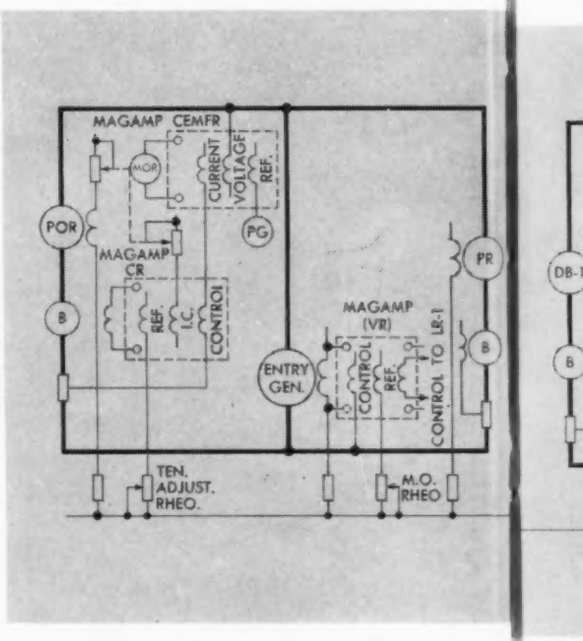
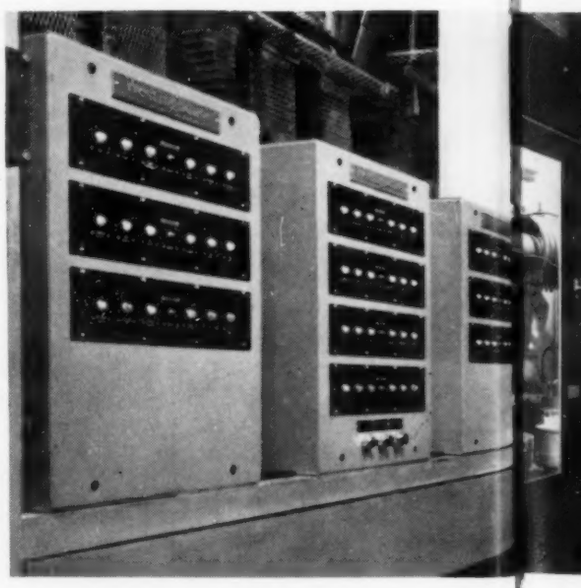
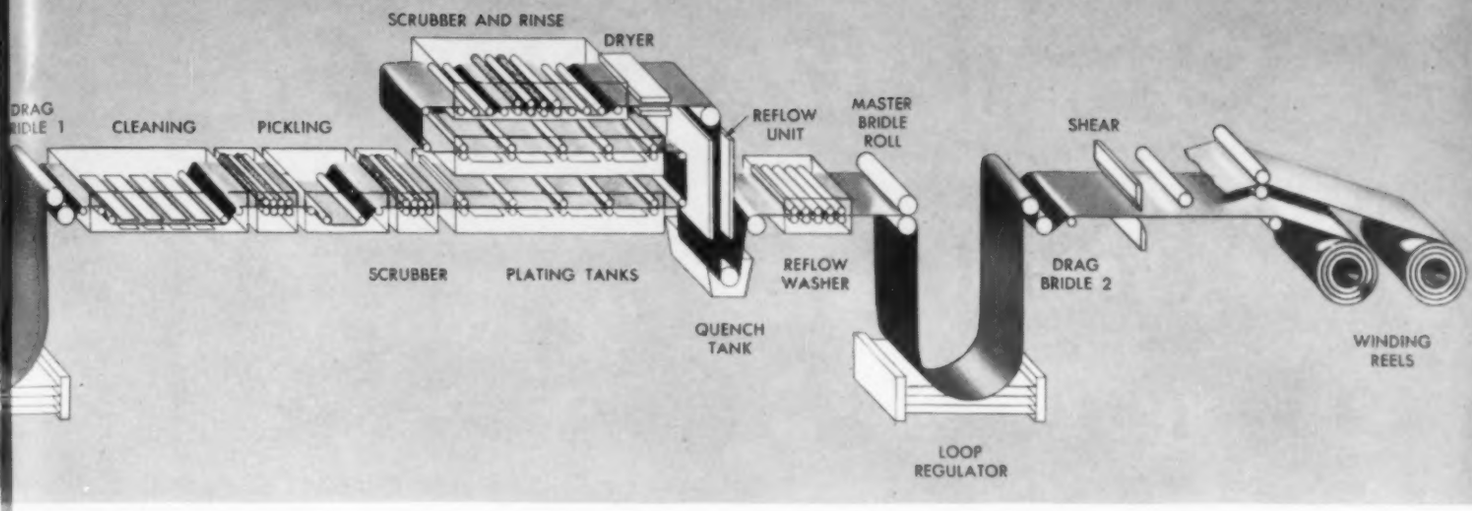


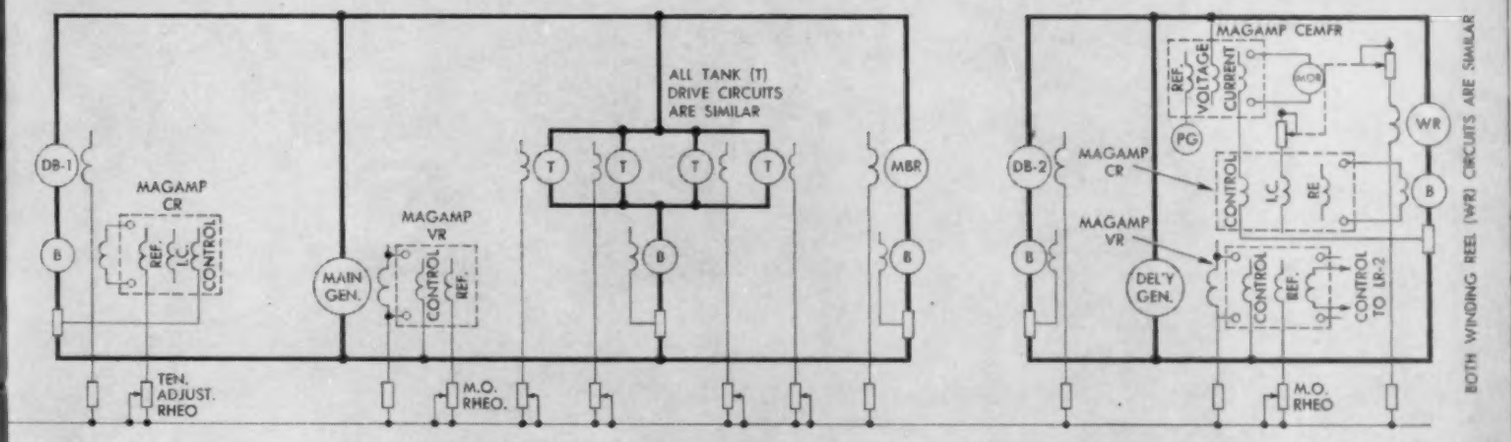




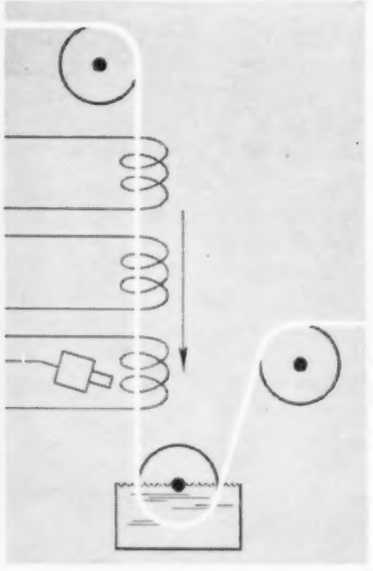
New Westinghouse fault finder monitors control circuits simultaneously, indicates system faults instantly . . . remembers them . . . makes trouble shooting easy.

ELECTROLYTIC TINNING LINE





Westinghouse 2400-kw oscillator equipment supplies high-frequency power to inductor coils. Generator output can be raised or reduced 90% in a couple of seconds.



Photoelectric scanner measures light reflection of passing strip, regulates radio-frequency power application in fraction of a second through saturable reactor.

WESTINGHOUSE EQUIPMENT SERVES THESE USERS

COMPANY	LOCATION	RATED LINE SPEED FPM	TIN FLOW EQUIPMENT
Jones & Laughlin Steel Corporation	Aliquippa, Pa.	600	600 kw, RF
Jones & Laughlin Steel Corporation	Aliquippa, Pa.	2100	1800 kw, RF
Republic Steel Corporation	Niles, Ohio	1000	1000 kw, RF
Republic Steel Corporation	Niles, Ohio	1400	1400 kw, RF
Steel Mill	California	1500	3000 kva, conduction†
Weirton Steel Company‡	Weirton, W. Va.	1300	1200 kw, RF
Weirton Steel Company	Weirton, W. Va.	1300	1200 kw, RF
Weirton Steel Company	Weirton, W. Va.	2100	2400 kw, RF
Weirton Steel Company	Weirton, W. Va.	2100	2400 kw, RF
Youngstown Sheet & Tube Company	Indiana Harbor, Ind.	600	600 kw, RF
Youngstown Sheet & Tube Company	Indiana Harbor, Ind.	2100	2400 kw, RF†

†Not yet in operation. ‡Division of National Steel Corporation.

Several other electrolytic tinning lines have Westinghouse conduction or radio-frequency reflow heating equipment, but line drives of another manufacture.

Westinghouse d-c motors withstand tough treatment because Bondite* and Bondar* insulations have twice the life expectancy of ordinary insulation. This means longer service from drive system, as well as the motors. *Trade-Mark

World's fastest tinning lines are Westinghouse-equipped

Engineering for electrolytic tinning lines is the most demanding in a steel plant, and Westinghouse pioneering in this field dates back to early attempts to deposit tin electrolytically on steel strip. Westinghouse has supplied all the electric line drive and tin reflow equipment for the higher speed horizontal acid type lines, and is now building equipment for the highest speed, vertical acid type.

The fastest tinning lines have as many as 150 individual d-c motor drives. Combining these drives, the generators that supply power to them, the 12 to 15 operators' stations, and the 100-foot-long controller into a coordinated drive system requires the kind of engineering and manufacturing talent Westinghouse can give you.

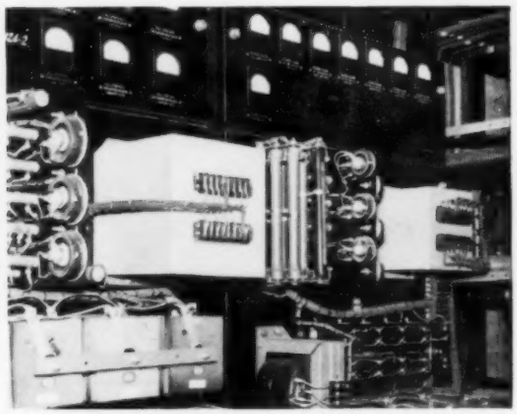
Reflow equipment, electro-cleaning and chemical treatment generators, switchgear, and numerous individual a-c motor drives and controls for pumps, scrubbers, welders and machinery adjustments must also be integrated into the system.

From planning to design, installation and start-up . . . Westinghouse brings decades of experience to you. A Westinghouse team will accept unit responsibility, and work with your engineering staff and consulting engineers in setting up your tinning line.

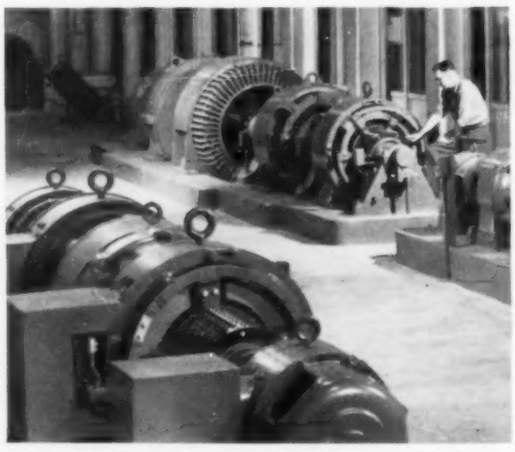
Contact your Westinghouse sales office for further details. Ask for a copy of B-6072, *Westinghouse Drives for Processing Lines.* Or write, Westinghouse Electric Corporation, 3 Gateway Center, P.O. Box 868, Pittsburgh 30, Pennsylvania.

YOU CAN BE **SURE**...IF IT'S

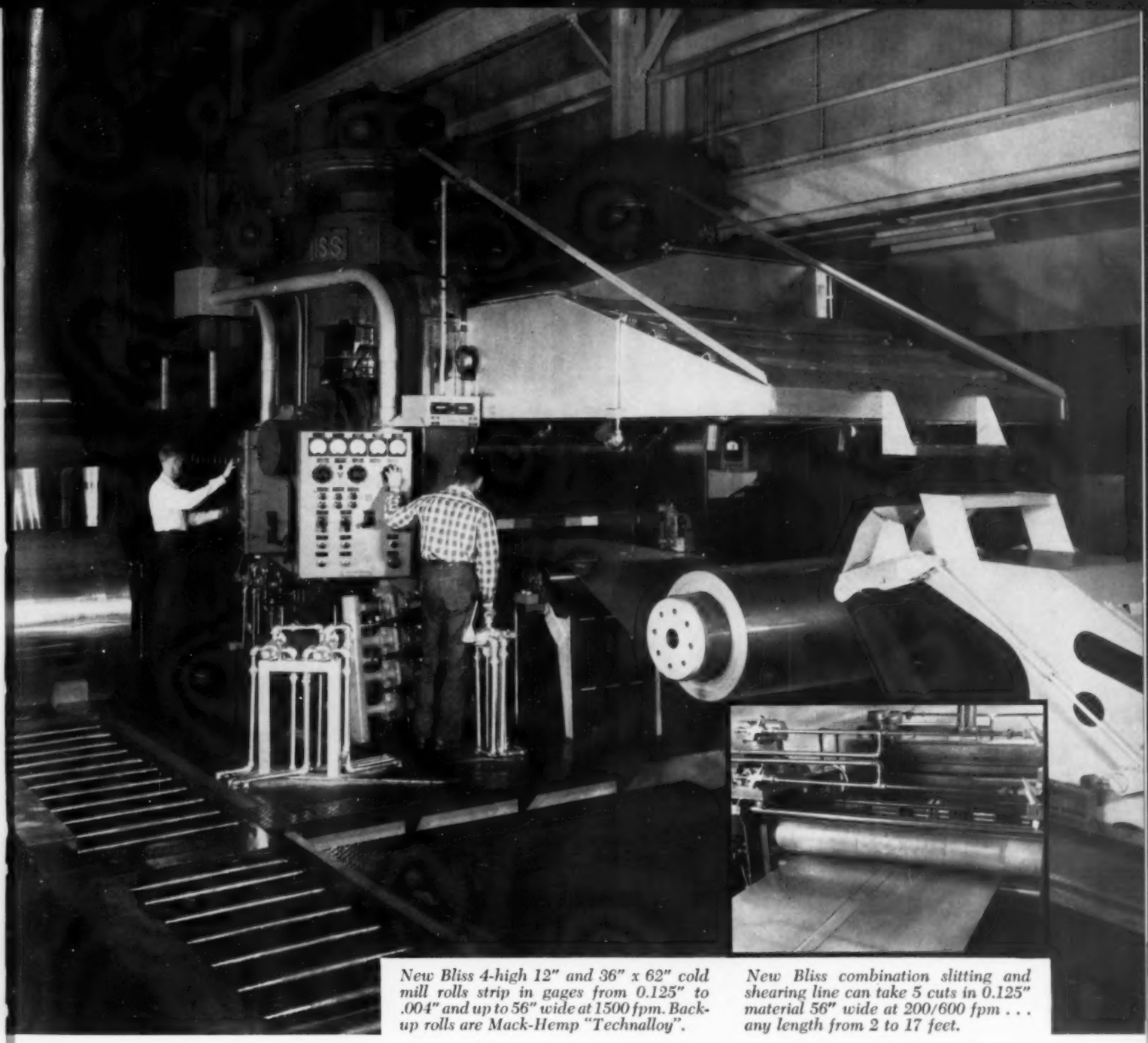
Westinghouse



Magamp regulators have no moving parts, brushes, commutators, bearings . . . bring outstanding precision, dependability to line drive control.



Westinghouse large motor-generator sets are built with Thermalastic® insulation which provides 20% greater dielectric strength, 10 times greater voltage endurance, 30 times greater tensile strength than ordinary insulation.



New Bliss 4-high 12" and 36" x 62" cold mill rolls strip in gages from 0.125" to .004" and up to 56" wide at 1500 fpm. Back-up rolls are Mack-Hemp "Technalloy".

New Bliss combination slitting and shearing line can take 5 cuts in 0.125" material 56" wide at 200/600 fpm . . . any length from 2 to 17 feet.

How to double rolling capacity—*FAST*

What can one new mill do? In the case of Sheet Aluminum Corporation, the answer is *plenty*. Here's what a new Bliss 4-high cold mill has done for this Jackson, Michigan, subsidiary of Mueller Brass Company:

• **More than doubled potential capacity,** from approximately 10,000,000 pounds of aluminum sheet and strip a year, to 25,000,000 pounds.

• **Increased the limit** on strip width from 24" to 56".

• **Simplified handling** by making it possible to roll much larger coils.

Of course, Sheet Aluminum had to make other installations to take full advantage of the new mill's capacity: a new continuous annealing furnace, a new Bliss slitting and shearing line, completely automatic coil handling equipment. But the fact remains that it's the mill that will do the heavy work.

Bliss' Rolling Mill Division engineers are expert in designing equipment that squeezes top production out of dollars invested. For other examples of their work, why not write today for your free copy of the 64-page Bliss Rolling Mill Brochure, Bulletin 40-A?

BLISS
SINCE 1857

100 years of making metal work for mankind

E. W. BLISS COMPANY, Rolling Mill Division, Salem, Ohio

Subsidiary: The Matteson Equipment Company, Inc., Poland, Ohio

HE KEEPS THEM ROLLING—
THE MAN FROM ATLANTIC

The Atlantic specialist in industrial lubrication is a highly skilled expert. He's spent years in the study of every heavy lubricating and cutting-oil problem . . . and he's backed by other Atlantic specialists in lubrication research, production, quality control and marketing.

Atlantic's experience since 1870 has made us familiar with *your* lubricating needs. We've developed the products necessary to do any lubrication job perfectly . . . at the lowest cost . . . for every wheel that turns in industry.

Your company can benefit from our extensive experience and services. For further information on Atlantic's family of products for industrial lubrication and metal processing, write or wire Dept. V-5, The Atlantic Refining Company, at the nearest office listed below.

ATLANTIC

LUBRICANTS • WAXES
PROCESS PRODUCTS

PHILADELPHIA, PA.
260 South Broad St.

PROVIDENCE, R. I.
430 Hospital Trust Bldg.

CHARLOTTE, N. C.
1112 South Boulevard

SYRACUSE, N. Y.
Salina and Genesee Sts.

READING, PA.
First and Penn Aves.

PITTSBURGH, PA.
Chamber of Commerce Bldg.

Atlantic Refining Company of Brazil
Edificio Castello
151 Avenida Nilo Pecanha
Rio de Janeiro, Brazil

Porto Rico Oil Company, Inc.
Box 4832, San Juan, Puerto Rico

He'll settle for perfection, nothing less

While a keyway is being milled in the neck of this hardened steel roll, the Bethlehem machinist is taking a final reading on the bearing diameter. Sure, it's been checked before, but he wants to be absolutely certain.

Despite the expert machining that is a part of every Bethlehem roll, inspections are numerous and thorough. The whole idea is to shoot for perfection.

The roll shown above will be used in the making of steel sheets and blackplate. It weighs in the neighborhood of 3½ tons; has a body length of 56 in. and a body diameter slightly over 21 in. The unit is typical of many that Bethlehem produces each year. But Bethlehem shops often make rolls weighing several times as much—as well as some so small that they can be lifted by hand. And all of them, large and small alike, receive the same careful workmanship, the same careful inspection.

Whatever your requirements, Bethlehem can meet them in full. Call us whenever you need rolls for cold-rolling steel sheets and strip . . . running down and finishing steps on copper and brass sheets . . . hot- and cold-rolling aluminum sheets . . . cold-rolling aluminum foil.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

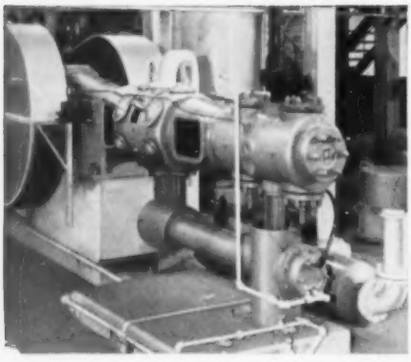
BETHLEHEM STEEL

BETHLEHEM STEEL

For jobs like THESE

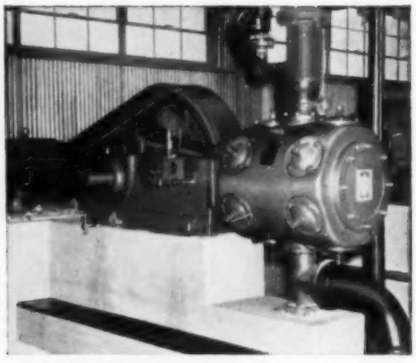
CHOOSE HEAVY-DUTY ES COMPRESSORS

for pressures to 2500 psi—sizes 5 to 150 horsepower

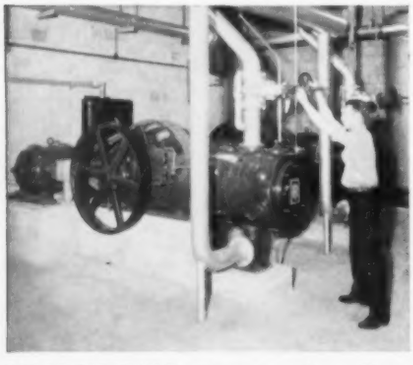


SOOT BLOWING The steam power plant of a large paper mill uses this ES to furnish high pressure air for boiler-tube soot blowing. This V-belt driven 125-hp unit compresses air to 350 psi in two-stages.

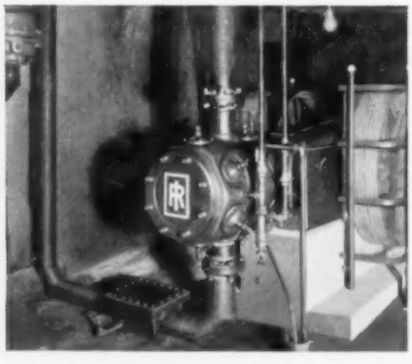
PROCESS GAS COMPRESSION In this unique outdoor installation, a two-stage ES compressor with V-belt drive compresses still vapors in a large modern gasoline plant.



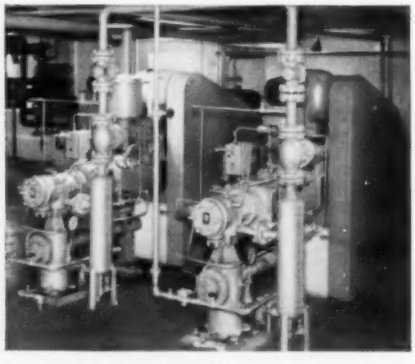
AIR LIFT SERVICE Shown here are two of the three Ingersoll-Rand ES compressors installed in a copper mine to provide pressure for elevating acid from the bleaching tanks by the air-lift principle.



GLASS MOLDING Here in a large lamp manufacturing plant, two ES compressors supply 50-psi air for cooling gas furnaces and for high pressure gas jets used in glass molding. Pressure is reduced to 30 psi to drive air-motor driven agitators.



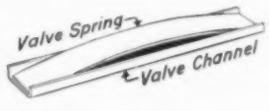
BOOSTER SERVICE Installed on the 4600 ft level of a large mine, this Ingersoll-Rand ES compressor boosts air pressure to get full power out of rock drills and other air-powered equipment.



AIR STARTING SERVICE A large transcontinental pipeline station uses these two ES compressors to supply 250-psi starting air to its I-R gas engine compressors. Both have overhead motors and one unit is provided with a standby gasoline engine.

SHOWN here are just a few of the countless ways in which Ingersoll-Rand heavy-duty ES compressors are serving industry. A wide range of standard cylinder arrangements and types of drive enables them to meet virtually any operating conditions within their size and capacity limits. Their efficiency is high and operating and maintenance costs low. Ask your I-R representative for help in solving any compression problem.

Only I-R compressors have CHANNEL VALVES



Known for high efficiency, quiet operation and almost unbelievable durability. Entirely different. Each valve is a combination of rigid stainless-steel channels and leaf springs, with trapped-air spaces which give cushioned action.

Ingersoll-Rand

1-394 **11 Broadway, New York 4, N. Y.**

COMPRESSORS • GAS AND DIESEL ENGINES • ROCK DRILLS • PUMPS • TURBO-BLOWERS • AIR AND ELECTRIC TOOLS

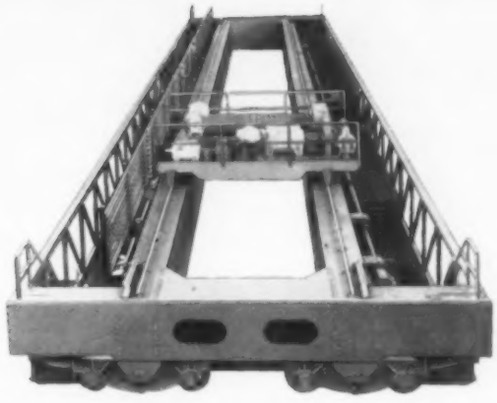
YOU NAME THE CRANE

"SHAW-BOX" WILL BUILD IT TO AISE SPECS OR YOUR OWN

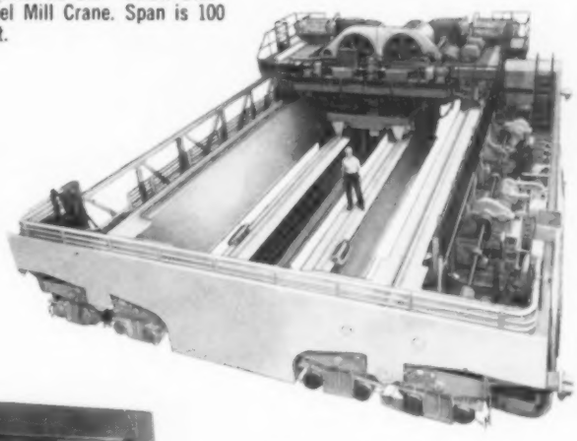
Ladle crane . . . plate or slab handling crane . . . trolley with worm-geared or spur-geared drive . . . soaking pit carriage — whatever your plans call for, "Shaw-Box" can be of service to you. In designing, engineering and building to AISE specifications or your own, we assure complete dependability and highest performance regardless of service conditions.

Mills everywhere have learned from experience that "Shaw-Box" know-how and vast production facilities save time, trouble and money. They know that "Shaw-Box" Cranes have many structural, mechanical and operational features that contribute to long-term satisfaction and economy.

One of our engineers will gladly discuss your specific problem and tell you about our standard AISE designs for cranes of 15 to 200-ton capacity. Your inquiry is invited.

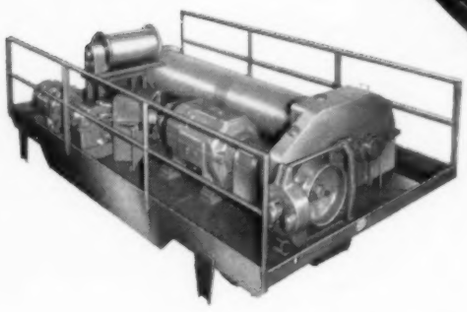


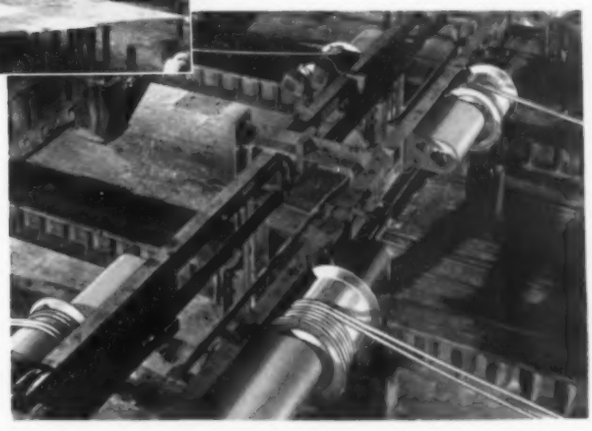
Typical 25-ton "Shaw-Box" Steel Mill Crane. Span is 100 feet.

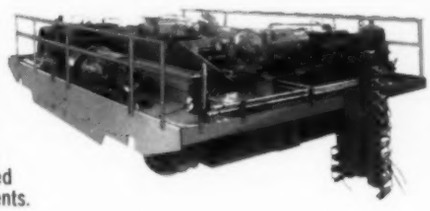


"Shaw-Box" Plate Handling Gantry equipped with lifting magnets.

This "Shaw-Box" Ladle Crane handles 200 tons of molten steel in a 90-ton ladle.







"Shaw-Box builds crane trolleys with spur-geared drive and with worm-geared drive. You can choose the type your experience has proved is most suitable for your requirements.

"Shaw-Box" Soaking Pit Carriages. The special "Shaw-Box" Spring Drive Cable Reels have automatic limit switches to cut off current when the carriages reach the end of travel in each direction.

57K-5

"Shaw-Box" ® CRANES

MANNING, MAXWELL & MOORE, INC.

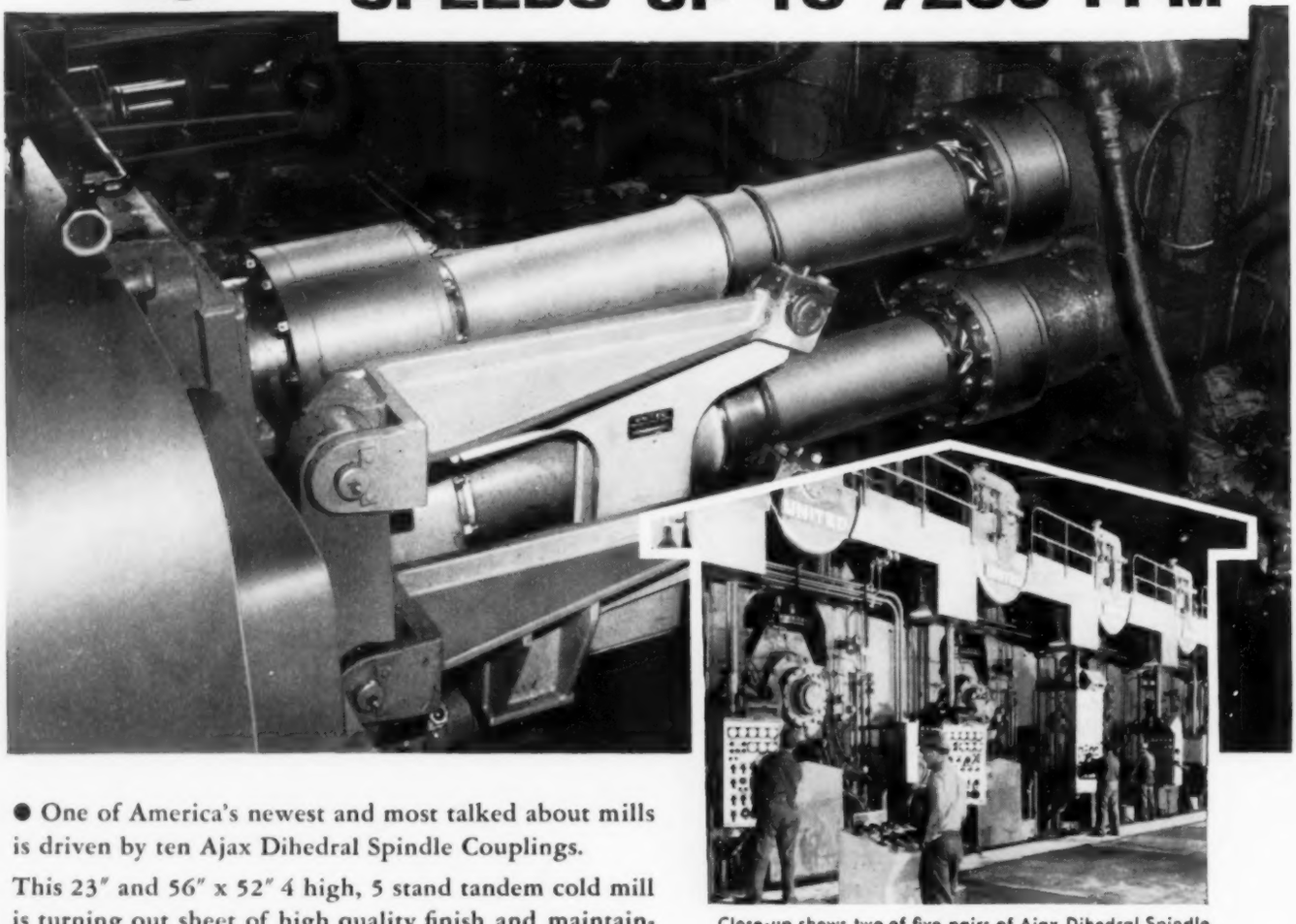
SHAW-BOX CRANE & HOIST DIVISION

388 West Broadway • Muskegon, Michigan

Builders of "SHAW-BOX" and 'LOAD LIFTER' Cranes, 'BUDGIT' and 'LOAD LIFTER' Hoists and other lifting specialties. Other Divisions produce 'ASHCROFT' Gauges, 'HANCOCK' Valves, 'CONSOLIDATED' Safety and Relief Valves. 'AMERICAN' and 'AMERICAN-MICROSEN' Industrial Instruments, and Aircraft Products.

In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Avenue Road, Galt, Ontario.*

DIHEDRAL SPINDLE DRIVE COUPLINGS HANDLE SPEEDS UP TO 7200 FPM



● One of America's newest and most talked about mills is driven by ten Ajax Dihedral Spindle Couplings.

This 23" and 56" x 52" 4 high, 5 stand tandem cold mill is turning out sheet of high quality finish and maintaining close gauge tolerance at speeds up to 7200 fpm.

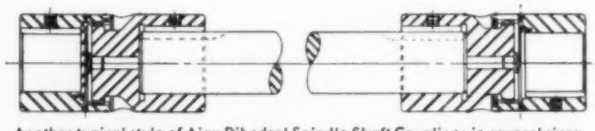
Uniform angular velocity made possible by Ajax Dihedral Spindle Couplings is an important factor in the performance of this high speed mill built by United Engineering & Foundry Co. for Weirton Steel Co., a Division of National Steel Corporation.

Each of these couplings delivers 2500 hp between drive stand and rolls.

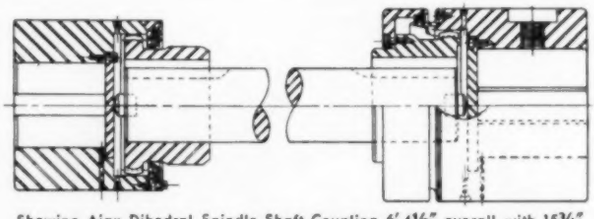
The proven performance of Ajax Dihedral Spindle Couplings is writing new standards into the specifications of mill builders and new figures into the production and maintenance cost records of mill users.

The long experience of Ajax engineers is available to help you in all phases of design, application and operation. Call in the Ajax representative or write us direct.

Close-up shows two of five pairs of Ajax Dihedral Spindle Couplings driving 23" and 56" x 52" 4 high 5 stand tandem cold mill built by United Engineering & Foundry Co. in operation at Weirton Steel Co., a Division of National Steel Corporation.



Another typical style of Ajax Dihedral Spindle Shaft Couplings in several sizes for roll mill drives. Sketch shows 9" diameter by 5'6" overall length Ajax Dihedral Spindle Shaft Coupling. Arranged for booted lubricant retainer seal.



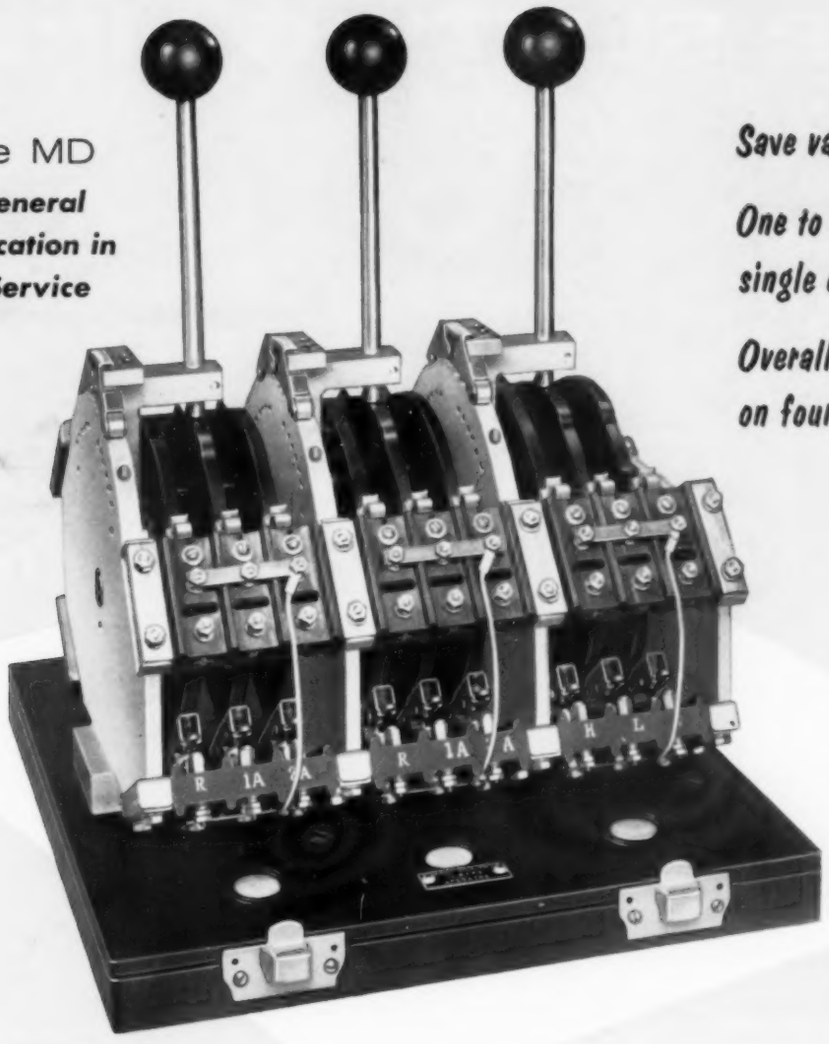
Showing Ajax Dihedral Spindle Shaft Coupling 6'4½" overall with 15¾" diameter coupling on roll end and 13¾" diameter coupling on drive end. Rated torque capacity of this Coupling is approximately 110,000 ft. lbs.

AJAX FLEXIBLE COUPLING CO. INC.

WESTFIELD, N. Y.

Type MD

for general application in Mill Service



Save valuable mounting space

One to four switches in a single enclosure

Overall length less than 22" on four unit switch

P-G master switches

Unique in design, the Post-Glover Type MD Master Switch saves valuable mounting space in crowded crane cabs or mill pulpits where sufficient room has always been a problem. Each single Master has a maximum of 12 circuits and up to 6 points either direction.

The operating lever has exceptionally short angular travel and can easily be adjusted in length, thus adding to operator comfort and efficiency.

Enclosure easily removed.

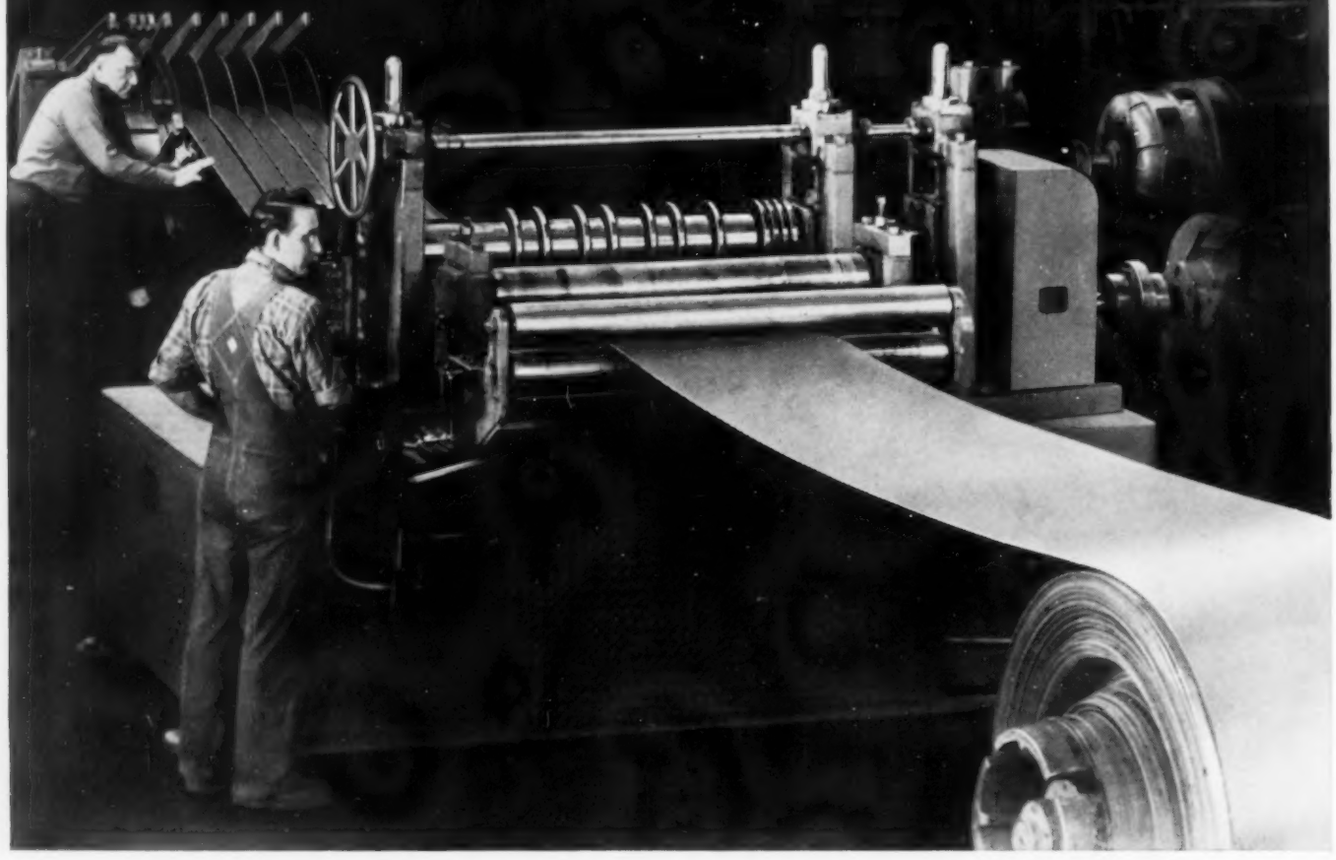
Write for Bulletin 410

THE **POST-GLOVER** ELECTRIC COMPANY

Established 1892

221 WEST THIRD STREET, CINCINNATI 2, OHIO

YODER SLITTING LINES



pay big dividends working only one day per week!

The Yoder Slitter Book is a comprehensive treatise on slitter operation and economics, with time studies, cost analyses and other useful data. It is yours for the asking.

In one plant, two Yoder tube mills and about 50 punch presses are being supplied with slit strands by one Yoder Slitting Line operated an average of only *seven hours per week.*

In another plant, a Yoder slitting line, *operated from six to eight hours per week,* is supplying two intermittently operated roll forming machines with total requirements averaging 100,000 feet per week.

These typical examples demonstrate, first, the big potential output of a relatively small, inexpensive Yoder standardized Slitting Line and, secondly, its big profitability. Assume production of only 35 tons of slit strands per 8 hour shift, one day per week, and the total per year would be 1750 tons. Estimating the saving in slitting cost at only one-half cent per lb., the total annual saving would be $17,500.00.

Besides the big convenience of doing your own slitting, such savings will often repay the investment in a few months.

THE YODER COMPANY 5495 Walworth Avenue • Cleveland 2, Ohio, U.S.A.

ENGINEERING YODER MANUFACTURING

ROTARY SLITTING LINES

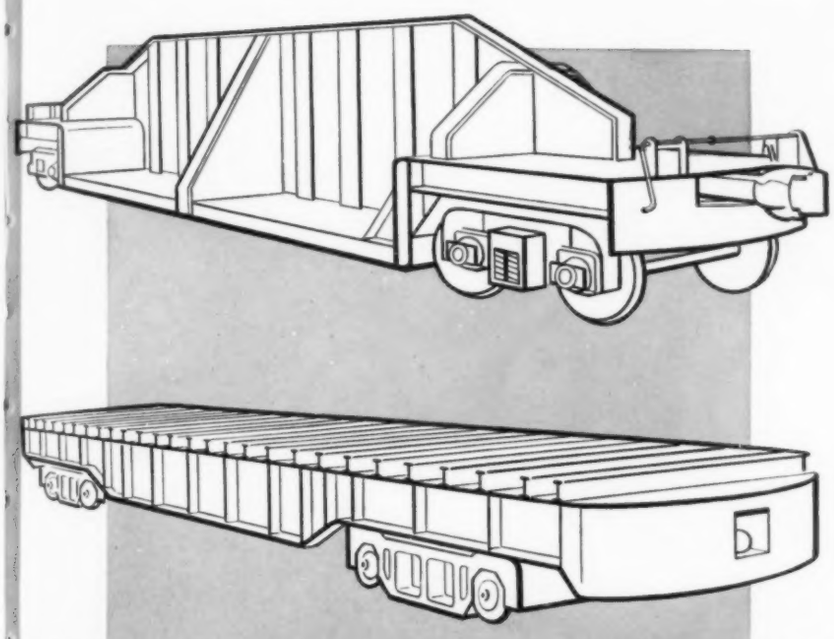
COLD ROLL FORMING MACHINES

ELECTRIC-WELD PIPE AND TUBE MILLS

COIL TRANSFER CARS

USS-DESIGNED

to your specifications



READY TO ROLL! The "camel back" car shown below transports coils of sheet steel to various processing locations. It has a 130-ton capacity and is 8′ wide x 34′8″ long, for use on standard gage track.

WHEN you're in the market for industrial cars, think of United States Steel. Our engineers will design cars to meet particular specifications and service requirements.

For example, the coil transfer car pictured here was designed by us to transport coils of sheet steel from one mill processing location to another. This "camel back" car has a capacity of 130 tons; it accommodates five 60-inch coils, weighing up to 50,000 lbs. each.

Car is of all-welded, rolled-steel construction, and its sides are fabricated from 24-inch CB wide-flange beams. Couplers are recessed, so the car can be pushed or pulled by floor tractors. If desired, the half-inch steel plates which form the coil separators can be covered with a protective material, making it possible to transport finished coils without danger of scratching them.

USS-Designed Coil Transfer Cars can be built in a wide variety of types and sizes. For more information on many kinds of industrial cars, send for a free copy of our 32-page illustrated booklet—"USS Custom Designed Cars." Our engineers will be pleased to call at your convenience to discuss your requirements for industrial cars.

USS INDUSTRIAL CARS

UNITED STATES STEEL CORPORATION, PITTSBURGH
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

United States Steel Corporation
525 William Penn Place, Room 2801
Pittsburgh 30, Pennsylvania

Please send me a free copy of your 32-page booklet, "USS Custom Designed Cars."

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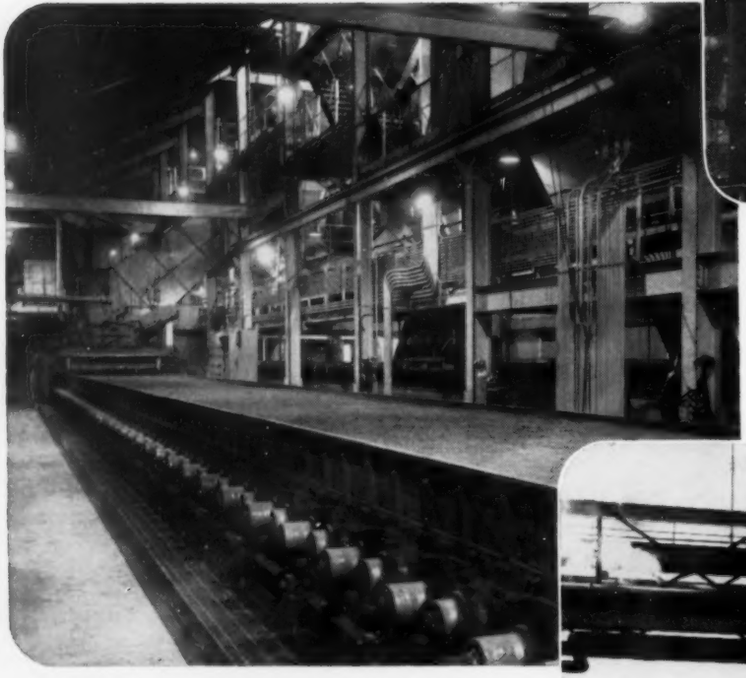
From ore-handling

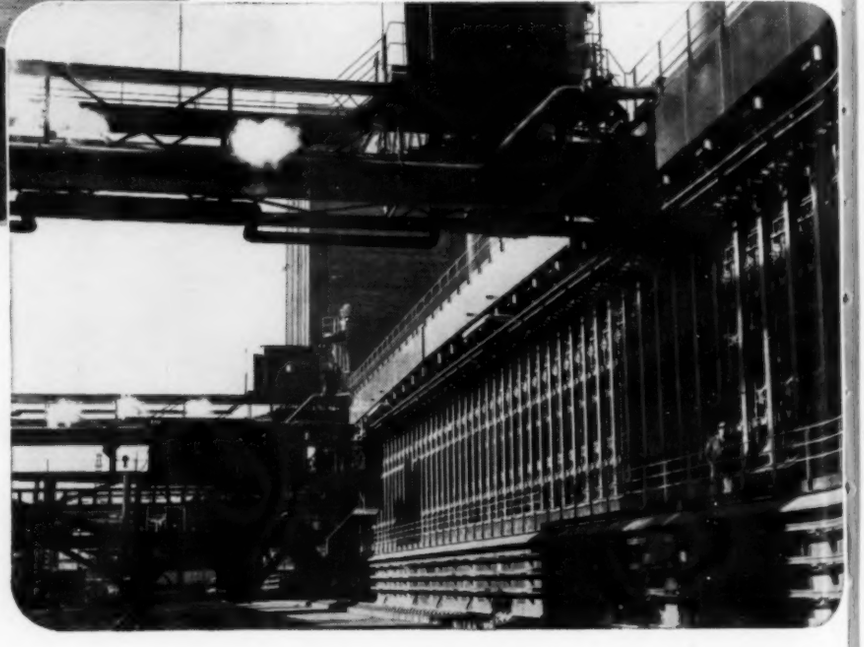
You can put

This ore-handling system was installed by Koppers for Great Lakes Steel Corporation in 1956 to speed up unloading of ore boats. Its capacity is 1,250 tons of ore an hour.

Biggest in the world, "A" blast furnace was designed and erected for Great Lakes Steel Corporation by the Freyn Department of Koppers. It has a hearth diameter of 30 feet, 3 inches . . . a total interior volume of 64,435 cubic feet.



8-foot-wide sintering machine, designed and constructed for Weirton Division of National Steel in 1955. This machine produces over 2,500 net tons of blast-furnace sinter a day. Now, Koppers Freyn Department is building two complete sintering plants—each with a 12-foot-wide machine—for National Steel Corporation.



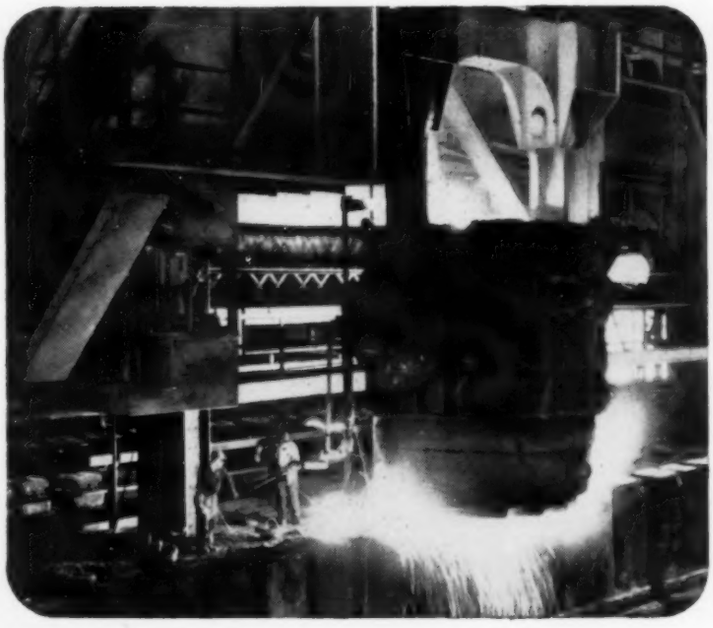
87 Koppers-Becker Coke Ovens, installed by Koppers Coke Plant Department in 1956 for Inland Steel Company's Indiana Harbor Works. This battery carbonizes 1,920 net tons of coal per day and is similar in design to an earlier battery of 65 Koppers Coke Ovens built in 1950.

to finished steel . . .

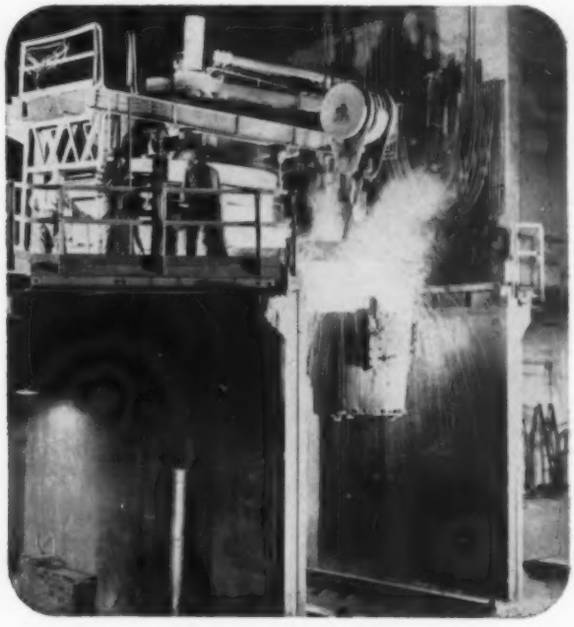
Koppers experience to work in your steel plant

For almost 50 years, Koppers has been designing, engineering and building steel plant installations. Koppers experience covers every step from original planning to final operation of materials handling systems, sintering plants, coke plants, blast furnaces and blast furnace equipment, open-hearth, electric-furnace and converter shops, rolling mill shops, and gas cleaning installations.

Put this experience and proved ability to work for your company. Call on Koppers next time *you* plan to build . . . rebuild . . . or expand. Koppers Company, Inc., Engineering and Construction Division, Pittsburgh 19, Pa.



This open-hearth shop, with eight furnaces, was designed and engineered for Youngstown Sheet & Tube Company by the Freyn Department of Koppers. Rated annual ingot capacity of the furnaces is 1,776,000 net tons. Koppers also designed a complete slabbing mill for this same company.



Electric-furnace shop, engineered and built in 1952 by Koppers Freyn Department to produce stainless and specialty steels for Allegheny Ludlum Steel Corporation at Watervliet, New York.

KOPPERS

KOPPERS

ENGINEERING AND CONSTRUCTION

What Rust-Oleum has saved for others is not half so important as the money it can save for YOU...

TRY RUST-OLEUM®

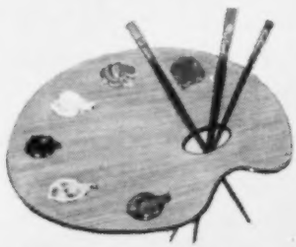
on your rustable metal surfaces under your own conditions

You've got to *try* Rust-Oleum *yourself* to get the feel of it . . . to see how *fast* it covers, how *easy* it works, how smoothly it flows on. You'll see the *big* savings in time, labor and money when you apply Rust-Oleum 769 Damp-Proof Red Primer over rusted metal—eliminating costly surface preparations. You'll see how the *specially-processed* fish oil vehicle *penetrates* rust to bare metal where it stops rust to assure long wear. You'll say you've never used a coating that went on so easily and covered so well. Try Rust-Oleum *soon*—in your plant or around your home. Write for illustrated literature with color charts.

Rust-Oleum Corporation, 2446 Oakton St., Evanston, Ill.

APPLY DIRECTLY OVER SOUND RUSTED METAL

No costly surface preparations usually required—just scrape and wire-brush to remove rust scale and loose rust—then brush Rust-Oleum 769 Damp-Proof Red Primer right over the remaining rust.



MANY ATTRACTIVE COLORS TO BEAUTIFY AS YOU PROTECT

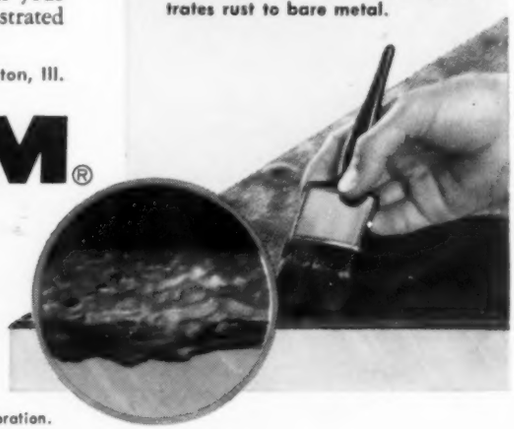
Colors, colors, colors—they're yours in many attractive Rust-Oleum finish coatings—including Aluminum, White, Red, Gray, Green, Blue, Yellow, Black and many more.

DISTINCTIVE AS YOUR OWN FINGERPRINT

Rust-Oleum is *exclusive*—with a specially-processed fish oil vehicle in both primers and finish coatings. Accept no substitute. Prompt delivery from Industrial Distributor stocks.

— — — — — — — — —

Write for special thirty-page report showing how Rust-Oleum penetrates rust to bare metal.



RUST-OLEUM®

STOPS RUST!®

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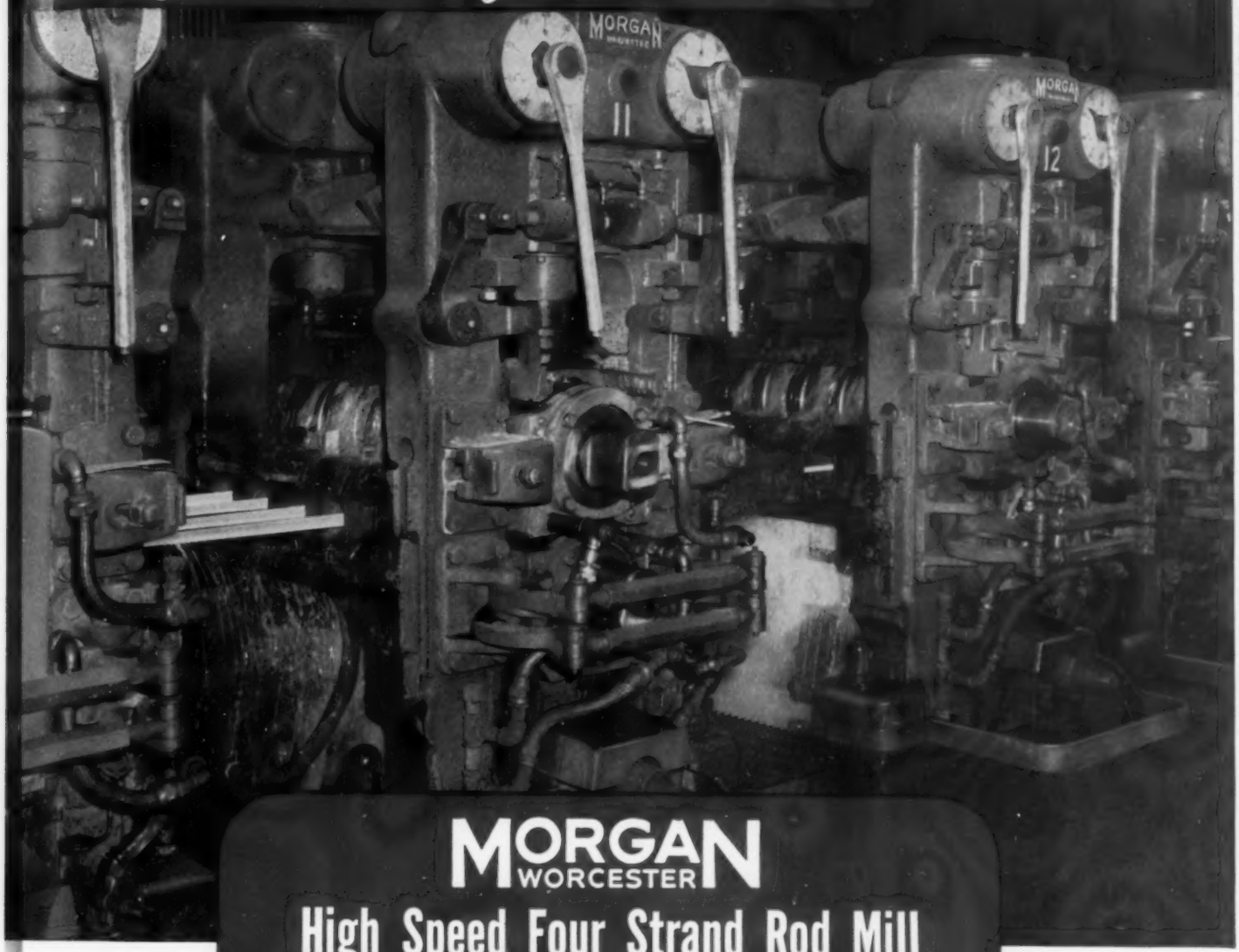
Morgan Quality in Action



MORGAN WORCESTER

High Speed Four Strand Rod Mill

Cuyahoga Works, American Steel and Wire Division
UNITED STATES STEEL CORPORATION

Morgan Mills are known to steel men throughout the world for their sound design and accurate manufacture . . . an enviable reputation which has assured mill users of efficient and trouble-free operation. Morgan Mills have kept pace with the ever-increasing demands for high output and greater accuracy of product.

MORGAN CONSTRUCTION CO.
WORCESTER, MASSACHUSETTS
ROLLING MILLS MORGOIL BEARINGS GAS PRODUCERS
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RM-70

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ALLIS-CHALMERS.

Products for steel: motors, m-g sets, control, pumps, *Texrope* drive equipment, crushers, mills, screens, rectifiers, transformers, substations, switchgear, circuit breakers, turbine-generators, voltage regulators, blowers, compressors, synchronous condensers, and water conditioning equipment.

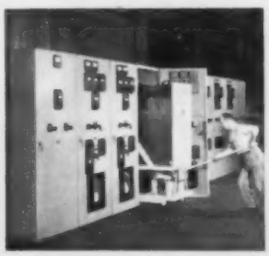
ALLIS-

. . in Step with STEEL

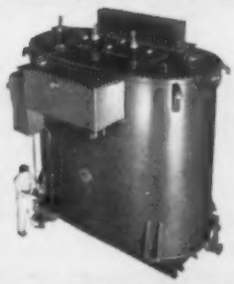
The arc furnace

Reduced costs result when Allis-Chalmers control, transformers and switchgear are specified for arc furnace application. The reason: A-C offers these products as a specially-integrated electrical system — designed by experts in furnace requirements and backed by Allis-Chalmers 75 years of experience in supplying equipment to the steel industry.

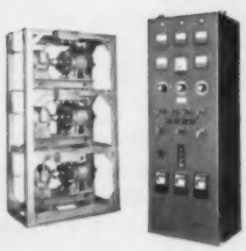
Wherever steel goes — from mine to final processing — Allis-Chalmers equipment is available to keep quality high, keep steel moving fast and profitably. Contact the A-C representative in your district, or write to Allis-Chalmers, Milwaukee 1, Wisconsin.



Arc furnace switchgear provides safe, dependable protection for transformer and related equipment. Special alloys assure long arcing contact life under severe interrupting duty, keeping maintenance and downtime to a minimum.



Transformers are of well-balanced designs and built for heavy duty . . . performance has been proven in 25-30 years of repeated daily short-circuits in electrical furnace operation.



. . . and Control requirements are met by Magnetic Amplifier and *Regulex* controls which balance arc current with arc voltage to maintain desired arc condition automatically. These controls result in high tonnage per kwhr, long life for electrodes and furnace linings, and a minimum of maintenance.

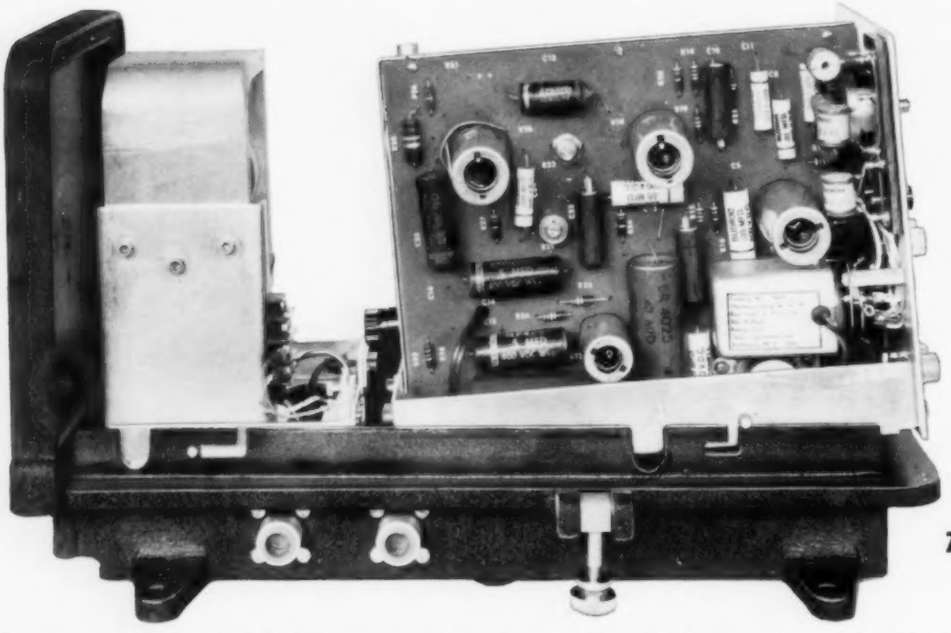
CHALMERS

Regulex and *Texrope* are Allis-Chalmers trademarks.

A-C ALLIS CHALMERS

A-5363

5 REASONS WHY A *Taylor* POTENTIOMETER TRANSMITTER WILL DO THE JOB BETTER!



700T Series

Converts any primary electrical signal into a 3-15 psi pneumatic output for controllers and receivers.

1. The unit is continuously standardized automatically. It assures complete electronic balance and permits optimum response adjustments. There are no slide wires, no batteries, no moving parts.

2. Easy continuous adjustment of range span and zero suppression—exclusive Taylor vernier adjustment gives exceptionally fine accuracy in calibration of the unit. You can completely change the range and zero suppression as plant conditions demand—only need one instrument as a spare.

3. Quick, simple removal for service with minimum instrument down-time . . . means that checking can be done efficiently in the shop where full facilities are available.

4. Modern printed circuits insure uniform performance because there's no variation between units. Principal electrical components are identified by engraved numbers on the phenolic board—another simplification for the maintenance technician.

5. Quickly adapted for use for different primary elements because you just plug in the corresponding service "can". "Most ingenious . . . and most practical"—that's what instrument men say about this important addition to the TRANSET* System.

That this ingenious instrument works so well in so many places is another reflection of the years of experience of Taylor instrument engineers in helping solve the problems of the processing industries.

Your Taylor Field Engineer can suggest where a Taylor Potentiometer Transmitter will help you in your processing picture. Write for **Catalog 98262.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

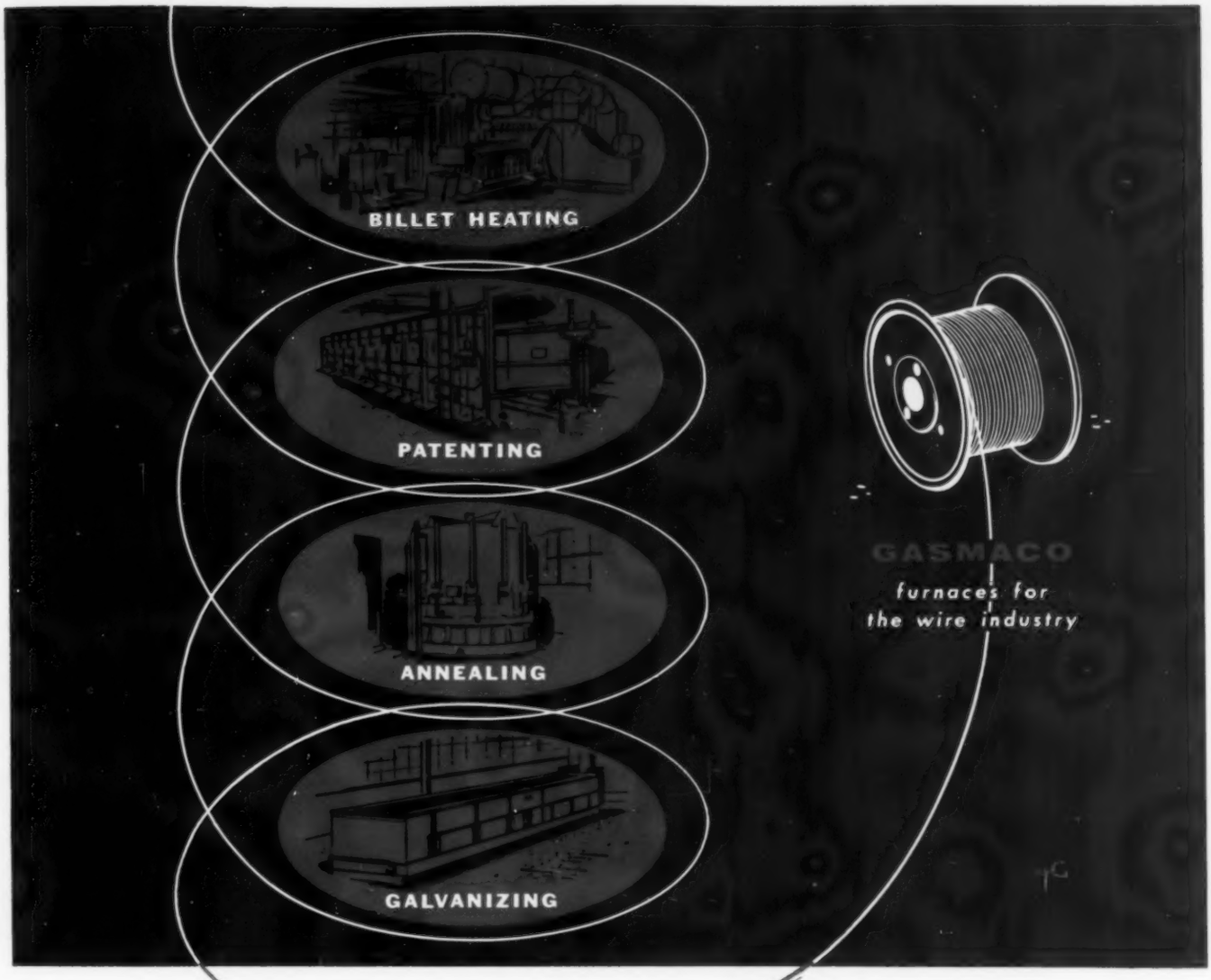
*Reg. U.S. Pat. Off.

Taylor Instruments

MEAN

ACCURACY FIRST

VISION · INGENUITY · DEPENDABILITY



WIRE MILL FURNACES

In the world of wire, the following GASMACO Furnaces are speeding production and improving quality . . .

BILLET HEATING—GASMACO reverse flueing . . . recuperative . . . designed to eliminate mill delay problems . . . single zone and double zone . . . up to 100 tons/hr.

PATENTING—GASMACO patented* silicon carbide radiant tubes permit high temperature operation with atmosphere . . . also direct-fired . . . either type supplied complete with lead quench or acid bath . . . up to 8000 lbs./hr.

ANNEALING—GASMACO single stack, direct-fired design . . . for rod or wire . . . alloy inner cover . . . tangentially fired . . . special pedestals.

GALVANIZING—GASMACO special design . . . fired along sides of tank . . . no flame impingement . . . reduces drossing.

THE GAS MACHINERY COMPANY, INDUSTRIAL FURNACE DIVISION
16128 Waterloo Road, Cleveland 10, Ohio
In Canada: The Gas Machinery Co. (Canada) Ltd., Hamilton, Ont.

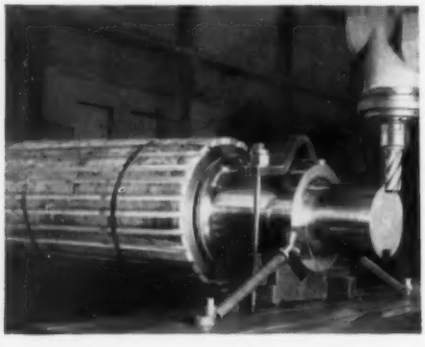
*Send for Bulletin A-106 GASMACO SILICON CARBIDE RADIANT TUBE FURNACE IMPROVES WIRE PATENTING OPERATION.

✓ *Check first with GASMACO for latest industrial furnace designs.*

THE **gas machinery** COMPANY

GAS PLANT EQUIPMENT
AND INDUSTRIAL FURNACES

Roll Turning—a Master's Art at BIRDSBORO



FINISHING SCHOOL for rolls at Birdsboro is the series of final machining operations performed to meet customer specifications. And no detail, down to the protective shipping crate, is left to chance.

Even though this man is only part of the large crew whose work has gone into this roll, he takes infinite care . . . for he knows that only the best possible craftsmanship will be accepted by his foreman. And it's the same in Birdsboro's research laboratories, as well as in the roll foundry. The results can be measured in your mill when you use Birdsboro's specialized family of steel, alloy iron, and alloy steel rolls, each member capable of meeting specific rolling requirements and taming temperamental hard-to-roll steels: IRON BASE ROLLS—Grainloy, Birdsboro Metal, Curoloy, Superloy, Super Curoloy; STEEL BASE ROLLS—Diamondite, Birdsboro Special, Birdsboro 30, 40, 50 and 75. Main office and plant: Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa., District Office: Pittsburgh, Pa., Subsidiary: Engineering Supervision Co., 120 W. 42nd St., New York 36, N.Y.

R-20-57

BIRDSBORO
STEEL FOUNDRY AND MACHINE CO.

STEEL MILL MACHINERY • HYDRAULIC PRESSES (Metalworking and Extrusion) • CRUSHING MACHINERY • SPECIAL MACHINERY • STEEL CASTINGS • "CAST-WELD" Design • ROLLS: Steel, Alloy Iron, Alloy Steel

NATIONAL BRUSHES
TRADE-MARK

are preferred for **TURBINE-GENERATOR COLLECTOR RING SERVICE**

GRADE 634

Designed for high speed excitation collector ring service.

The increased capacity of today's modern turbine-generator is directly related to increased excitation of the rotor. Here, where high-speed steel collector rings operate at peripheral speeds up to 15,000 fpm, "National" brushes Grade 634 provide low inertia as well as low wear rate on both brushes and rings. No wonder these service-proven brushes are universally preferred by turbine-generator manufacturers everywhere. If you are faced with a brush performance or commutation problem, feel free to call on NATIONAL CARBON for specialized advice.

UNION CARBIDE

The terms "National", "Union Carbide" and the Silver Colored Cable Strand are registered trade-marks of Union Carbide Corporation

NATIONAL CARBON COMPANY • **Division of Union Carbide Corporation** • *30 East 42nd Street, New York 17, N. Y.*

SALES OFFICES: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco • **IN CANADA:** Union Carbide Canada Limited, Toronto

Turn Rolls *Automatically* with "YOUNGSTOWN"

CONTOUR ROLL LATHE

with Hydraulic Tracer Control

Above Roll Lathe 36" maximum roll diameter.

Other capacities: 48" — 60"

Designed to turn rolls better in any plant... from the smallest rod mill to the largest blooming mill

f&Ym *features:*

- The rigidity of turning in neck housing and bearings eliminates tool chatter; allows heavier cuts and reduces tool cost.
- Complete hydraulic tracer control insures smoother, more accurate finish.
- Tool post and carriage designed to use either single point carbide-tipped tools or regular high speed tool steel roll turning tools.
- Ways on carriage and tail stock are non-metallic, which greatly extends service life.
- Timken roller bearings throughout herringbone gearing; automatic lubrication.

"YF&M" precision-built lathes turn rolls (either on necks or centers) with accuracy and fine finish. They have utmost rigidity and necessary speeds to cut hard alloy iron and mild steel rolls, with exceptionally low tool cost. These lathes are also available without tracer control, for cutting down back-up rolls and for cutting spalls from strip mill rolls. Tell us your needs.

The Youngstown Foundry & Machine Co.

SERVING INDUSTRY SINCE 1885

Youngstown, Ohio

how's this for *performance?*

15 lbs. of scrap after cutting 156 parts from a 6′ x 10′ plate of ⅜″ steel

Using four torches guided by an electronic tracer, an Airco #48 Duograph automatically flame cut 156 parts from a ⅜″ x 72″ x 120″ steel plate. Of the original 918 pounds of sheet steel, only 15 pounds of scrap remained. Discover the advantages to be gained by using Airco flame-cutting machines for fast, economical production. In addition to the #48 Duograph, Airco flame-cutting machines include the Airco Travograph, Oxygraph, Duograph, Monograph, Camograph, and Radiagraph. Write Airco for complete information and literature.

welding
AT THE FRONTIERS OF PROGRESS YOU'LL FIND . . .

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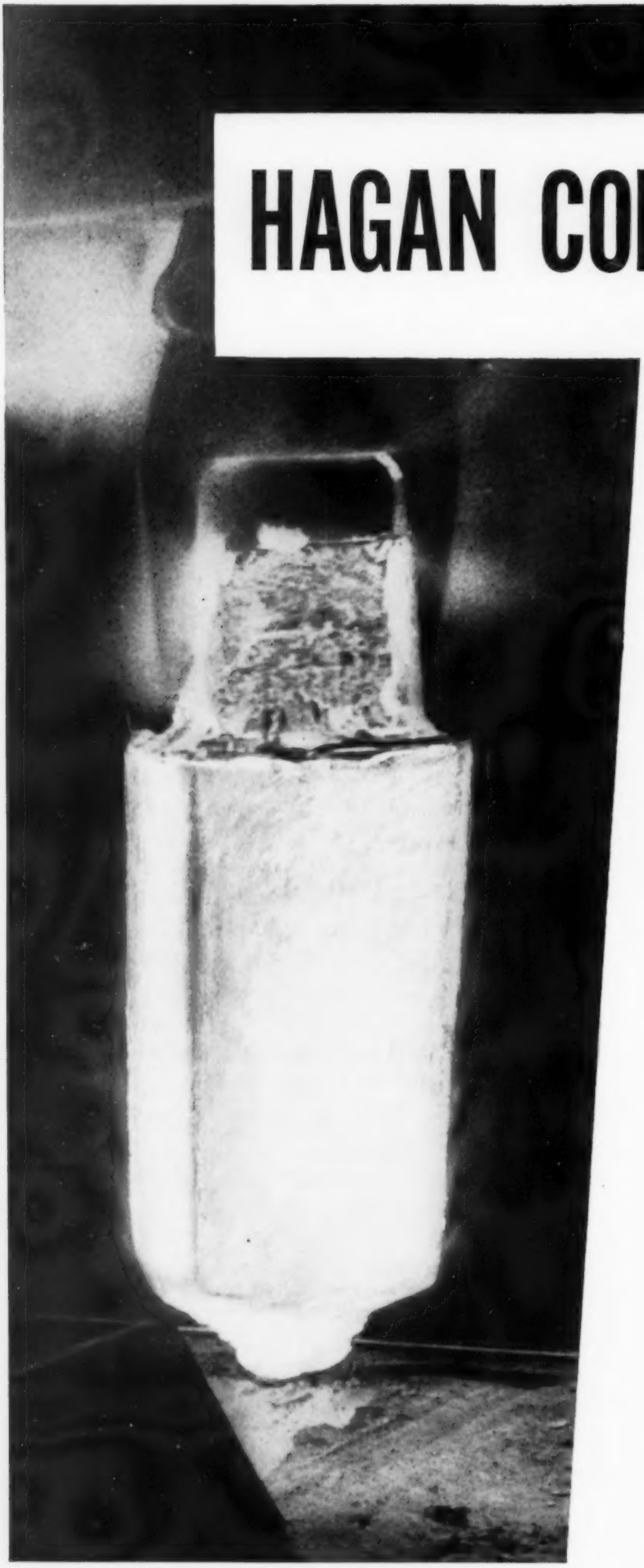
Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** — industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** — carbon dioxide — gaseous, liquid, solid ("DRY-ICE") • **OHIO** — medical gases and hospital equipment • **NATIONAL CARBIDE** — pipeline acetylene and calcium carbide • **COLTON** — polyvinyl acetate, alcohols, and other synthetic resins.



HAGAN CONTROL helps

Flexibility of Hagan control system permits solution of ingot heating problem at Crucible Steel's Midland Plant.

Faced with the need for better circulation at low fuel input, Crucible's engineers adjusted the Hagan Fuel-Air regulator so that it was biased to produce automatically an accurately measured dilution of the gas-air mixture at low flows (from 106% theoretical air during the heating period to 215% theoretical air during the soaking period). No scale problem was encountered.

This gave the effect of firing a low Btu gas and achieved the desired uniformity of heat distribution. Tons per hour increased, and Btu's per ton decreased.

The engineers were very satisfied with the results achieved by this change, and made the comment, "We were fortunate in having a control flexible enough to do this."

Hagan control components are built with this particular objective in mind. Every unit is designed to offer engineers wide latitude not only in application, but also in performance. Hagan instruments and controls are dependable, extremely accurate and versatile. Why not discuss your control and instrumentation problems with the Hagan engineer. He can help you find a solution.

solve a soaking pit problem

NOTES ON THE HAGAN INSTALLATION AT CRUCIBLE STEEL'S MIDLAND PLANT.

Fuel-Air Ratio Control

A high degree of accuracy is achieved in this part of the Hagan soaking pit control. In normal operation, a double diaphragm regulator controls the ratio by pneumatically repositioning the combustion air valve. This normal operation can be varied by moving the fulcrum of the ratio regulator. This is provided by:

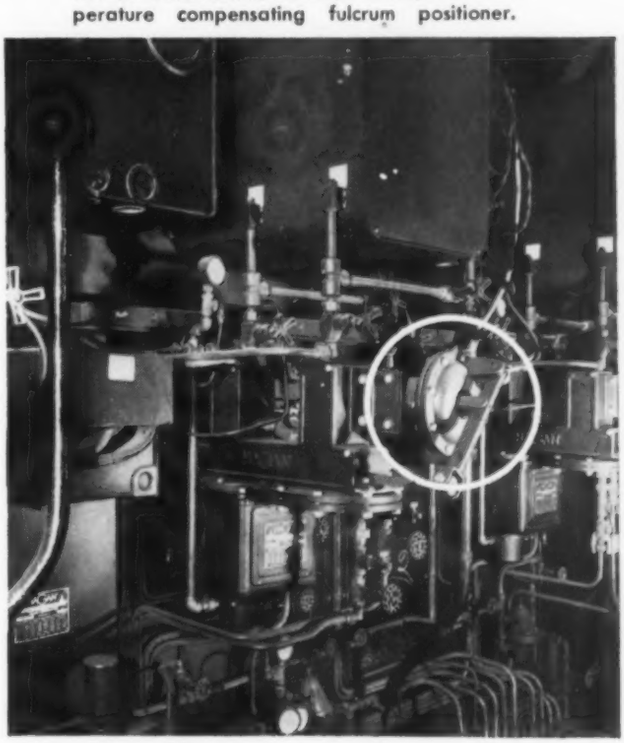
Combustion Air Temperature Compensation

By means of an air temperature transmitter, connected to a thermocouple in the hot air duct, a pneumatic signal is transmitted to a diaphragm operator. This operator serves as a fulcrum positioner for the fuel-air ratio regulator, so that the ratio is maintained despite variations in combustion air temperature.

Hagan control systems are also used for collector flue draft control, pit pressure measurement, recuperator temperature control and measurement and for the safety systems. These various parts of the overall system are functioning accurately and dependably, and actual records show extremely low maintenance costs. To quote the Crucible engineers again, "Considering the types of steel being heated, controlled-heating cycles required, and track times, we believe the pits are doing an excellent job."

Reprints of an article, "Problems of a New Soaking Pit Installation" are available. Write for your copy.

Control panel for Crucible Soaking Pits.



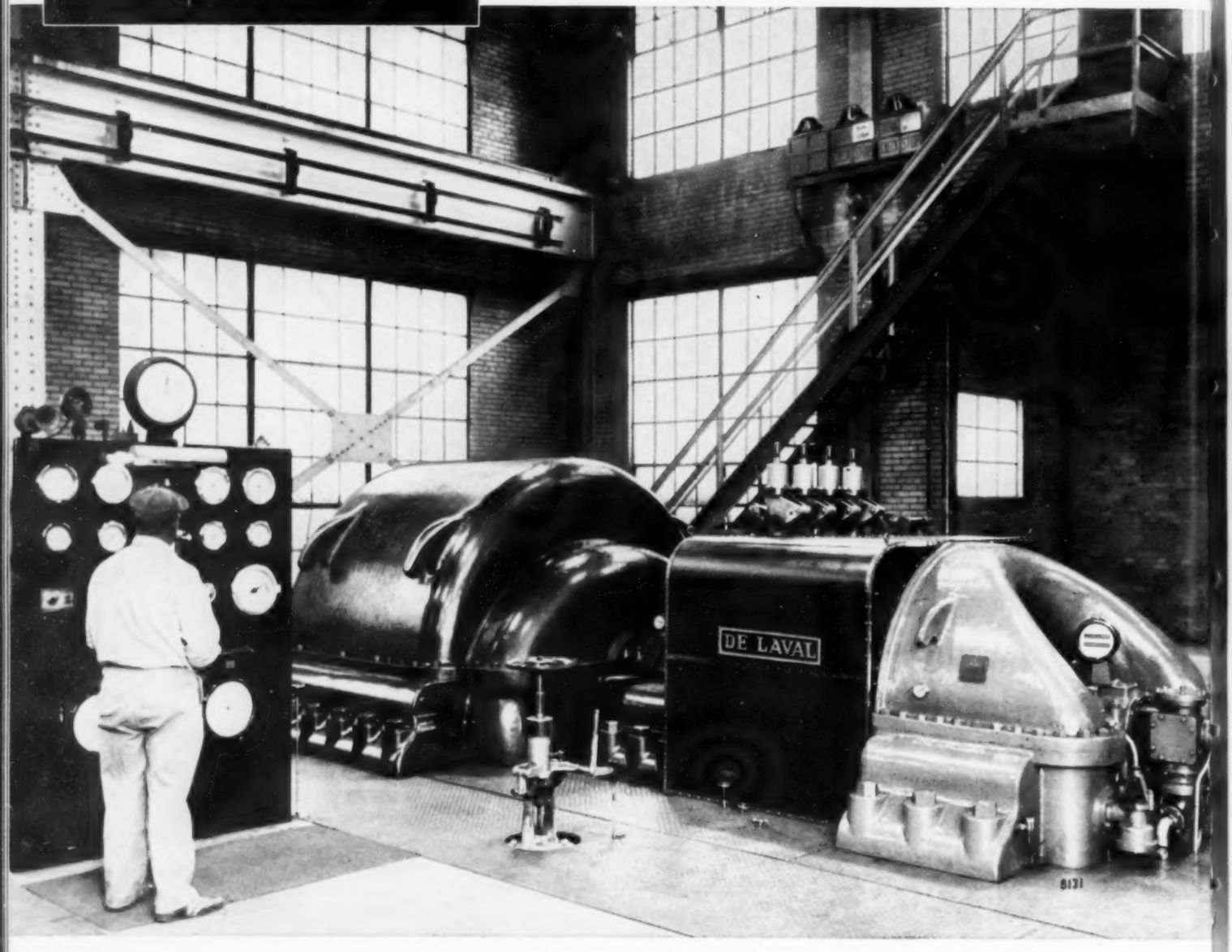
Back of panel, showing double diaphragm fuel-air ratio control and (in circle) the temperature compensating fulcrum positioner.

HAGAN CHEMICALS & CONTROLS, INC.

HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES

DE LAVAL
BLAST FURNACE BLOWERS

give 20 years of service at Great Lakes Steel Corp.



Shown is one of two De Laval centrifugal blast furnace blowers at the Ecorse, Michigan, plant of the Great Lakes Steel Corporation, Division of National Steel Corporation. This 85,000 cfm unit was installed twenty years ago; another 75,000 cfm unit went on the line a year earlier. Both have given dependable round-the-clock service ever since. These turbine-driven blowers are hooked up to a multi-head which enables either one to be used in conjunction with any of the three blast furnaces.

De Laval centrifugal blowers are built in single and multi-stage types to supply air in volumes up to 150,000 cfm for all classes of service in steel, gas and coke plants. The wealth of application experience acquired by De Laval over the years assures a correct and economical solution to your blower problem.

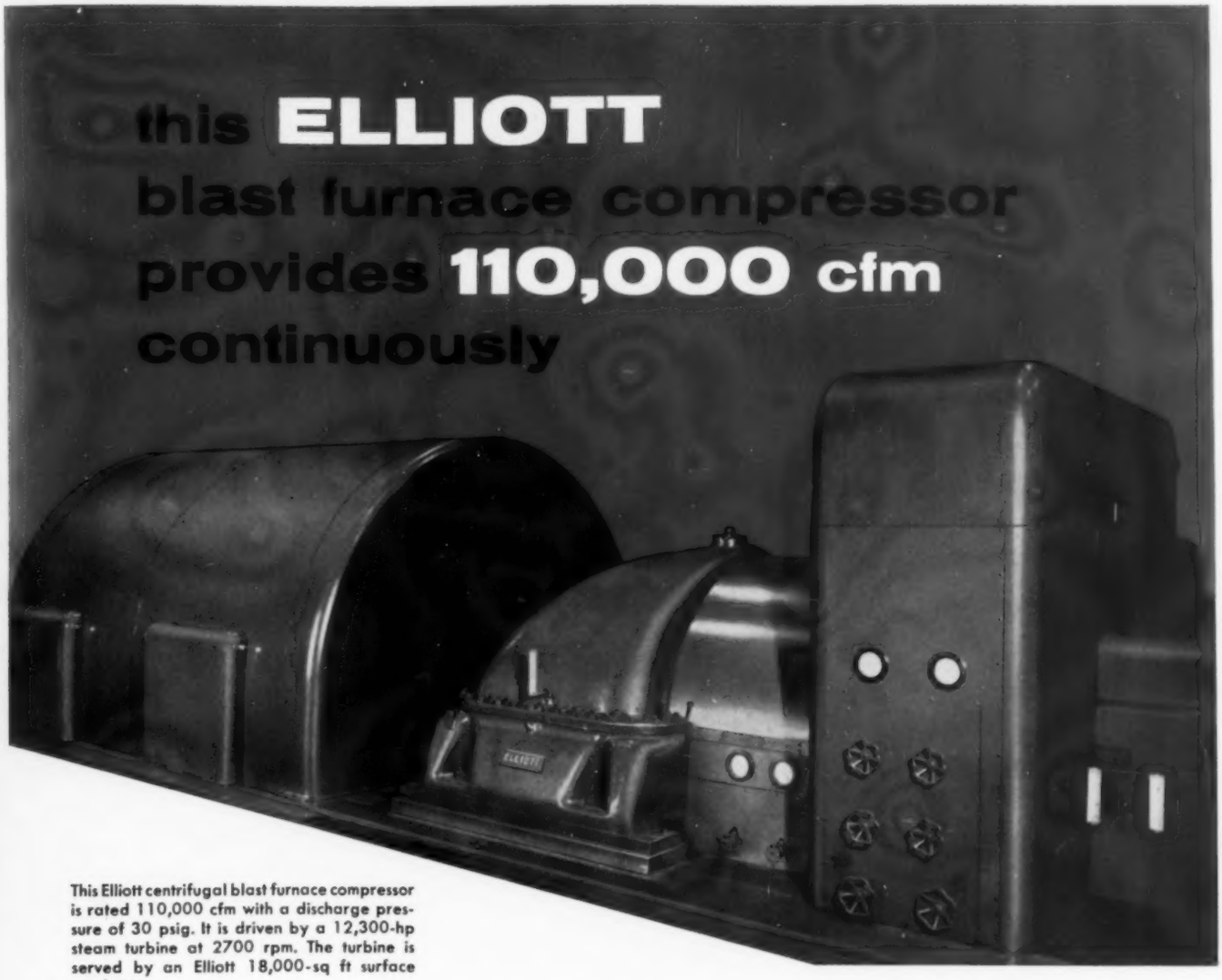
Send for Bulletin 0504

DE LAVAL *Centrifugal Blowers*

DE LAVAL STEAM TURBINE COMPANY
870 Nottingham Way, Trenton 2, New Jersey

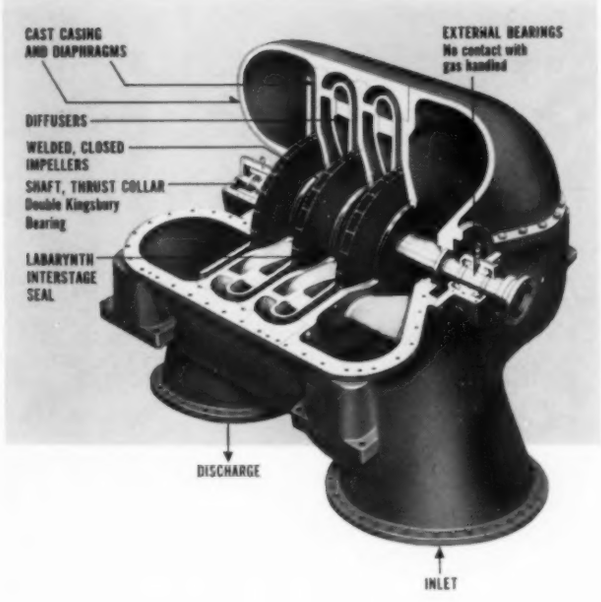
DL-381

this ELLIOTT blast furnace compressor provides 110,000 cfm continuously



This Elliott centrifugal blast furnace compressor is rated 110,000 cfm with a discharge pressure of 30 psig. It is driven by a 12,300-hp steam turbine at 2700 rpm. The turbine is served by an Elliott 18,000-sq ft surface condenser.

modern design features add up to top, non-stop performance



Talk about air supply for modern blast furnaces and you're talking about compressors which must operate continuously and efficiently—day in and day out—year after year. This is where all Elliott-engineered centrifugal compressors demonstrate their superiority.

The Elliott turbo-compressor-condenser unit shown above serves one of the newest and most modern blast furnace plants. It is driven by a turbine which is a modification of the modern Elliott design used for large turbine-generator units. The neat appearance and ruggedness of the unit is matched by its efficient, dependable operation. Elliott compressors are available in multi-stage types with inlet capacities up to 150,000 cfm.

For descriptive literature write . . .

ELLIOTT Company
Centrifugal Compressor Department, Jeannette, Pa.

P7-2

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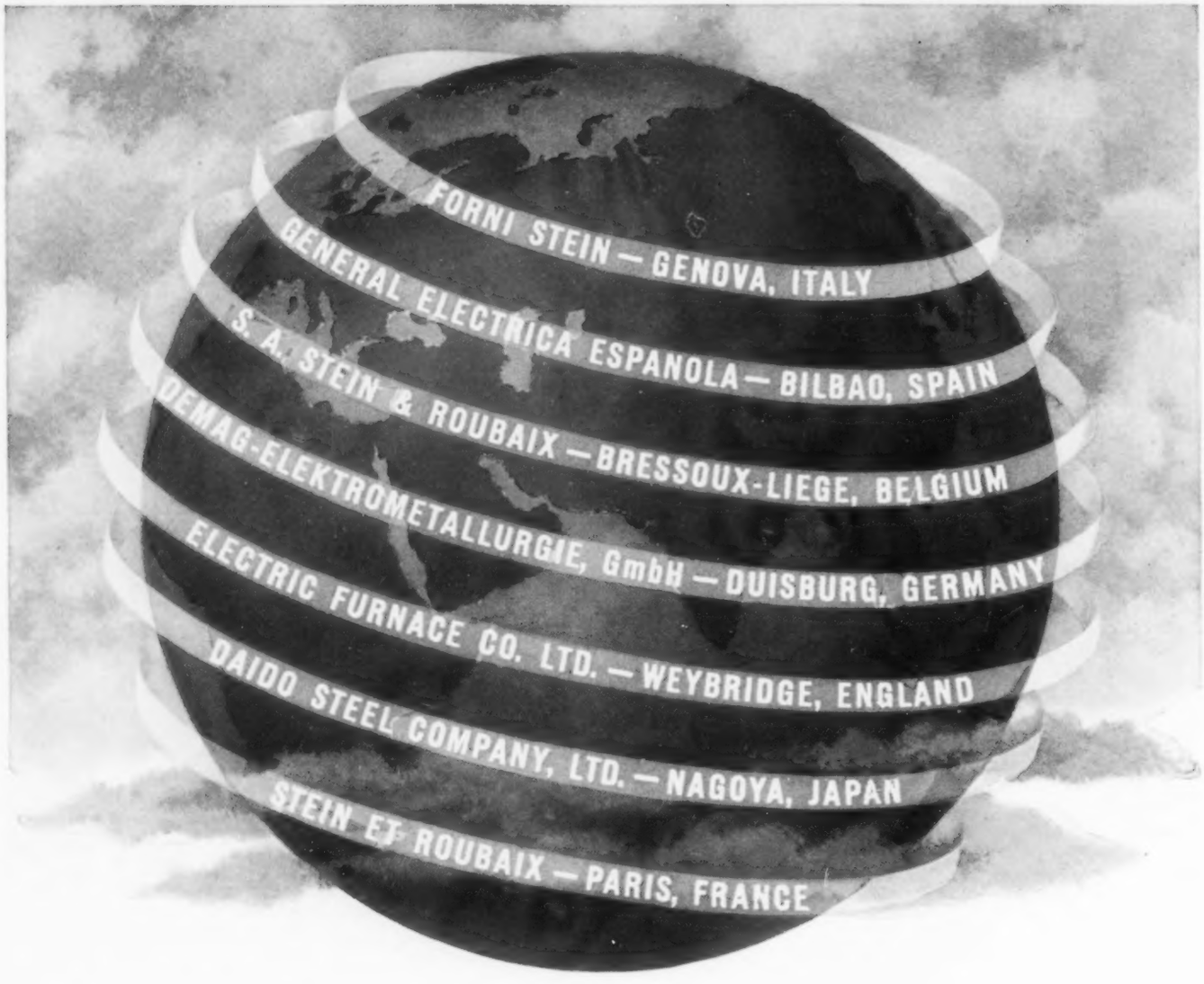
FORNI STEIN — GENOVA, ITALY
GENERAL ELECTRICA ESPANOLA — BILBAO, SPAIN
S. A. STEIN & ROUBAIX — BRESSOUX-LIEGE, BELGIUM
DEMAG-ELEKTROMETALLURGIE, GmbH — DUISBURG, GERMANY
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DAIDO STEEL COMPANY, LTD. — NAGOYA, JAPAN
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'round the world they go . . .

Lectromelt* FURNACES

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....several items probably can cause so-called "snaky edge" defects....one likely offender happens in the annealing cycle where keeping the CO/CO_2 low will eliminate this defect in a number of cases....sluggish gas flow also contributes to undesirable reactions during heating.

study of factors influencing SURFACE STAINING OF COLD ROLLED STEEL

PART I

TYPES OF DEFECTS AND THEIR OCCURRENCE

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▲ THE work described in this paper has been devoted to an analysis of the nature of a commercially important surface defect of cold rolled steel known as "snaky edge." This defect is worthy of study because of its common occurrence, the difficulty of getting rid of it, and the expense involved for the industry in reprocessing of material rendered unsuitable for many surface finishes because of "snaky edges."

No direct attempts have been made to simulate mill conditions, the entire laboratory effort being expended, rather, in two related directions: first, variations of annealing conditions to remove "snaky edges" produced commercially, and second, determination of the combination of factors which may lead to the development of the defect. Deductions from the results of these investigations have been used as the basis for more restrictive experiments and for recommendations regarding practical ways to minimize the occurrence of the defect.

Figure 1 — View of annealing apparatus shows: (1) tank gases, (2) flow meters, (3) dew point control, (4) dew point measurement, (5) retort (retracted), and (6) furnace.

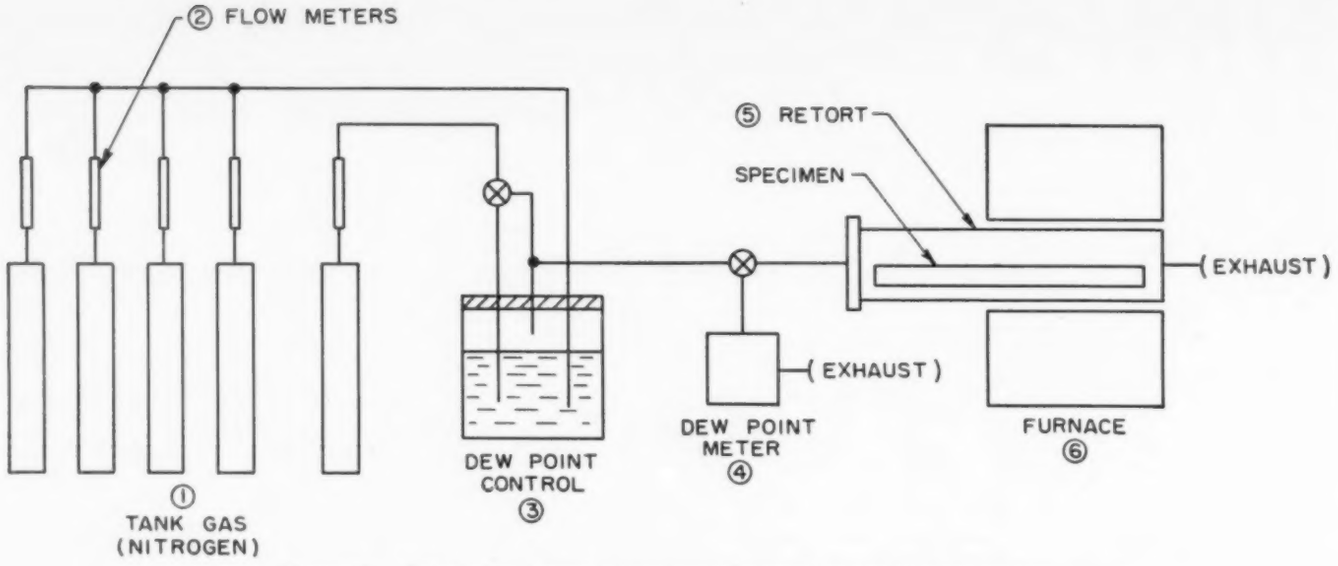


Figure 2 — Schematic layout shows experimental annealing apparatus.

EXPERIMENTAL PROCEDURE

Equipment—The annealing equipment used consists of a resistance wound electric furnace with a chamber 5 x 7 x 18 in., a retort of 3-in. diam stainless steel, 21 in. long, and a battery of tanks of purified gas. The apparatus is shown in Figure 1, and schematically in Figure 2. The composition of the gas fed to the tube is controlled by passing each gas separately through a calibrated flowmeter and mixing them in a manifold prior to their entry into the furnace. Dew point is controlled by bubbling part of the gas through water in a container held in a constant temperature bath. The retort may be fed with gas either from the rear, or hot end in the furnace, or through the front, or cold end, which projects from the furnace. Gas seal is maintained on the furnace by clamping a flange against a neoprene ring set in a groove in the retort. The gasket is cooled by water flowing through several turns of copper coils wrapped around the retort at the flange end. Composition of the gas can be checked by an Orsat apparatus. Flow rate may be checked by a precision flowmeter. Dew point may be checked by an Alnor dewpointer.

Removal of "snaky edge" defect—Experiments were aimed at effecting the removal of the "snaky edge" defect on the assumption that some clues to its identity and source would be derivable.

On commercial material the defect occurs as a black band about ½ to 1 in. wide, running parallel to each edge of annealed strip and separated from the edge by a bright, clean zone of about the same width. On annealed sheet the band appears parallel to all four edges. A distinguishing characteristic is the sharp line of demarcation between the bright and dark areas. Generally, the black zone fades into a grayish area in the center of the strip width. An example of a commercially produced "snaky edge" is shown in Figure 3.

Pieces were cut from commercial strip exhibiting the black defect and subjected to various annealing treatments. The small samples were supported on a steel rack in the hot zone of the retort in such a way that a maximum amount of surface was exposed to the action of the gases. The DX gas used had the composition given in Table I.

Treatment for up to two hours at 1285 F in DX gas had no effect on the appearance of the defect. Treatment in dry hydrogen under the same annealing conditions also produced no noticeable change. Upon increasing the annealing temperature to 1475 F, exposure to dry hydrogen for an annealing time of two hours was ineffective, but after six hours the surface stains were completely removed. Carbon is removed by the formation of methane.

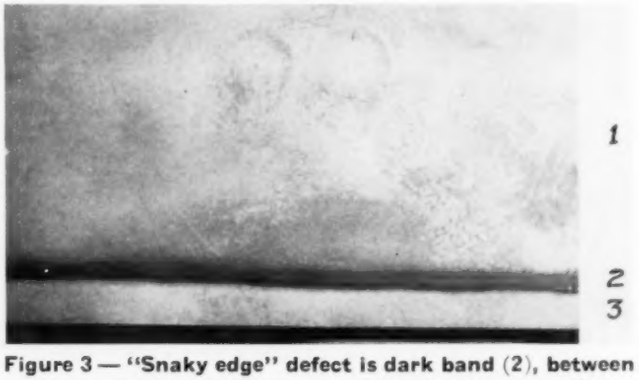


Figure 3 — "Snaky edge" defect is dark band (2), between central area of strip (1), and bright outer edge (3).

Using the annealing conditions of six hours at 1475 F in dry hydrogen, an evaluation was made of the possible effect of residues of rolling mill lubricants on the removal of "snaky edge" stains. Coating the surface with a light film of rolling oil did not interfere with complete removal of the defect. Further experiments, in which the film of rolling oil on the sample was sprayed with either of two commercial rolling mill detergents, or in which the detergents were sprayed directly on the

TABLE I
Composition of DX Gas*

Per cent by volume						Dew point (F)
CO_2	CO	H_2	CH_4	N_2	H_2O	
5.0	10.5	12.5	0.5	70.7	0.8	40

* Surface Combustion Corporation data.

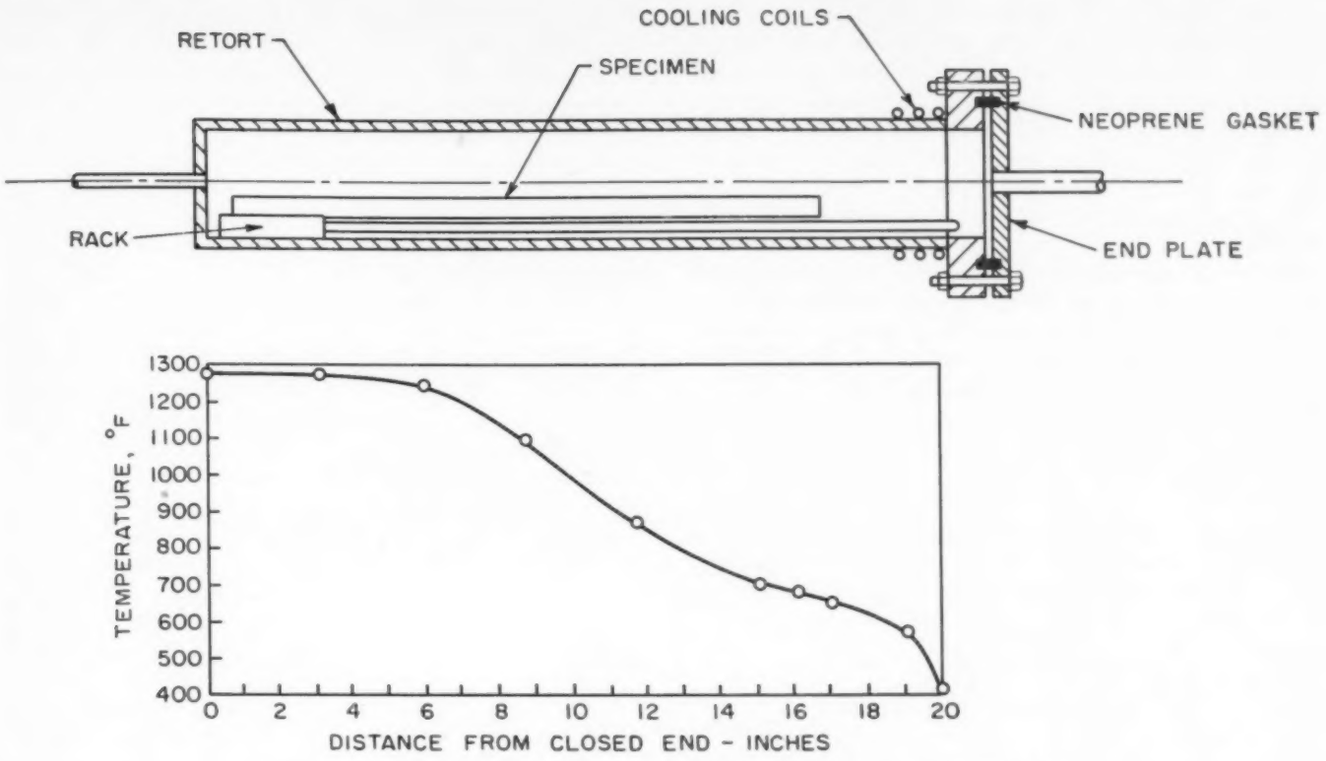


Figure 4 — Sketch shows construction of retort and temperature gradient.

strip, showed that these products did nothing to prevent or inhibit the removal of the stain.

Since chemical analyses have shown that the black deposit consists essentially of a mixture of iron oxides and carbon, a corollary annealing experiment suggested itself. Pieces of clean, cold rolled strip were oxidized in air at temperatures from 700 to 1300 F and subjected to the action of DX gas at 1285 F. Both black Fe_2O_4 and red Fe_2O_3 were easily removed in less than half an hour under these annealing conditions. The resistance of the "snaky edge" defect to removal by DX gas must, therefore, be due to something other than its content of iron oxide. It was also implicit in these results that the defect might be formed on the heating cycle in annealing, since it would not be removed by subsequent exposure to DX gas.

Laboratory production of a "snaky edge" stain— Based partly on the results reported above, experiments were performed in which 16-in. long strips of cold rolled steel were placed in the annealing retort as shown schematically in Figure 4, upper part. Since the retort is partly out of the furnace, a temperature gradient exists along the tube, as indicated in the lower part of Figure 4.

With DX gas flowing into the retort from the cold end of the apparatus, and with the hot end of the strip at 1285 F, a pronounced stain pattern is produced on the strip, as may be seen on the lower strip in Figure 5. The surface of the strip is bright in the temperature zones above 1000 to 1100 F, and carries various oxide colors at lower temperatures. However, a black sooty deposit is formed in a band corresponding to the temperature range of 900 to 950 F. In its appearance, including a sharp demarcation line, this black zone resembles a commercial "snaky edge" defect. It will be shown in Part II of this paper that there are also chemical similarities between the black zones produced experimentally and commercially. The strip shown in the upper part of Figure 5 exhibits a different pattern produced when the DX gas is introduced at the hot end of the retort. The black zone is not formed, and only light oxidation takes place in the 900 to 950 F zone.

On the assumption that the optimum temperature

Figure 5 — Appearance of gradient strips after annealing in DX gas; 1 cfhr; 2 hr at 1285 F.

for synthesizing the black stain was about 950 F, strips were gradient annealed with the hot end held at 950 F. Contrary to expectation, the black zone now appeared at a position on the strip corresponding to a temperature range of 700 to 750 F. It now appeared that a temperature gradient was required to produce the stain, not a specific temperature.

Next, the effect of substances present on the strip surface on the appearance of the gradient annealed strips was investigated. The pattern was essentially unaltered by the presence of a light film of oil or oil plus detergent placed on the surface prior to annealing. In addition, the surface was cleaned in various ways prior to annealing: by chemical solvents, by electrolysis in sodium carbonate solution, and, very severely, by mechanical polishing. The stain pattern produced by gradient annealing was essentially the same in all cases.

Effect of restricted gas flow—In the commercial annealing of coils, access of the gas to the strip surfaces is restricted by tight winding of the coils. The possible influence of this factor on the formation of the "snaky edge" defect was investigated by clamping a stack of samples together and exposing them to DX gas. A stack of four to eight pieces of sheet about 1½ in. square were held between two square plates of ¼-in. mild steel, bolted at the corners. About ½ in. of one edge of the "sandwich" was allowed to protrude. It was found that when such a pack was heated for two hours at 1285 F in DX gas introduced from the cold end of the retort, a black stain occurred along the line of clamping on the internal mating surfaces. The chemical composition of this deposit was also found to be similar to that of a commercially formed "snaky edge."

TABLE II
DX Gas of Variable CO/CO_2 Ratio

Per cent by volume						Dew point (F)	CO/CO_2 ratio
CO_2	CO	H_2	CH_4	N_2	H_2O		
5.8	8.8	11.5	0.4	73.5	0.8	40	1.5
4.9	9.7	11.5	0.4	73.5	0.8	40	2
3.6	11.0	11.5	0.4	73.5	0.8	40	3
2.4	12.2	11.5	0.4	73.5	0.8	40	5
1.3	13.3	11.5	0.4	73.5	0.8	40	10

Effect of time, temperature, and gas composition on staining—The foregoing results pointed toward the carboniferous gases in the DX composition, CO and CO_2, as probable sources of the carbon in the "snaky edge." Also, the thesis that a reaction taking place at intermediate temperatures during the heating cycle produced the "snaky edge," led to the setting up of a tightly controlled laboratory experiment in which samples of cold rolled strip were exposed to a gas whose CO/CO_2 ratio was varied over wide limits, at various temperatures, and for various lengths of time.

This was accomplished by preparing a number of pieces of cold rolled steel, sheared ½ in. square, and carefully cleaned in acetone and stored in a desiccator prior to the experiments. Thirty pieces were selected and stencilled with a code to indicate the gas composition and temperature to which they would be subjected. Each of these pieces was encapsulated in a vycor bulb, 16 mm in diam, and about 2½ in. long, representing a volume of about 10 ml. Calculations showed that if 1000 Å of both surfaces were reacted completely in every conceivable way with both CO and CO_2, only about 1.5 per cent of the available carboniferous gases would be consumed; therefore, it appears safe to assume that the gas in the bulb will remain of constant composition throughout the experiment.

The gas compositions used in the experiment are shown in Table II. The first composition given, with a CO/CO_2 ratio of 1.5, is that of the DX gas used in a plant which is never afflicted with the "snaky edge" defect.

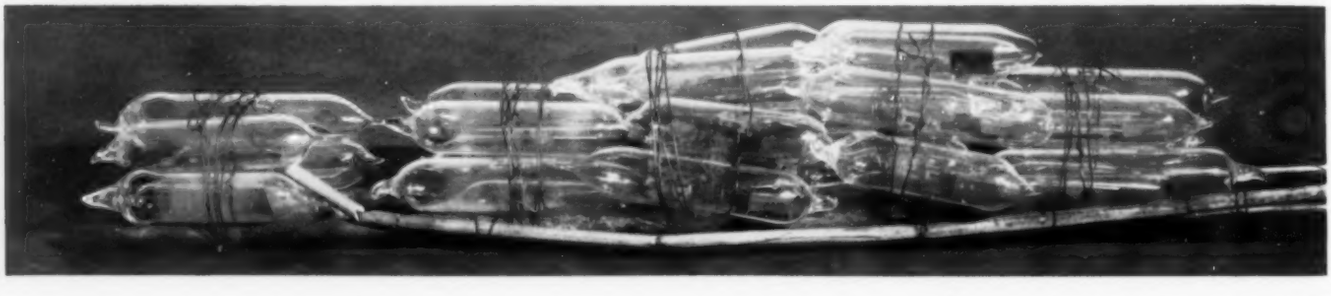
The temperatures to be investigated were those lying at 100 F increments between 1250 and 750 F.

These six temperatures required five bulbs of each composition. The gas compositions were made up using the apparatus previously described, and each composition in turn was stored in a 20-liter glass carboy. The gas compositions were analyzed and showed actual CO/CO_2 ratios of 1.5, 1.94, 2.9, 5.1, and 9.5, which are gratifyingly close to those desired. The carboy was sealed, carried to a vacuum glass-sealing apparatus, and the gas pumped into the bulbs prior to sealing off their open end. A different partial pressure of gas was introduced into each bulb prior to sealing, calculated to produce one atmosphere pressure in the bulb at its particular annealing temperature.

After sealing, the bulbs were arranged in clusters of five at six points along the length of a fixture, located in such a manner that the steel samples in each set were at the proper temperature along the gradient in the retort. The appearance of the assembly is shown in Figure 6. The fixture was then heated and removed at various time intervals for examination of staining of the steel pieces. The time intervals selected were 15 min, 30 min, 1 hr, 2 hr, 8 hr, and 32 hr. A record was made of the appearance of each sample after each heating period.

The results of this experiment are shown plotted in Figure 7, where the surface appearance after 32 hr

Figure 6 — Arrangement of encapsulated specimens used in measuring the effect of gas composition and temperature on surface staining.



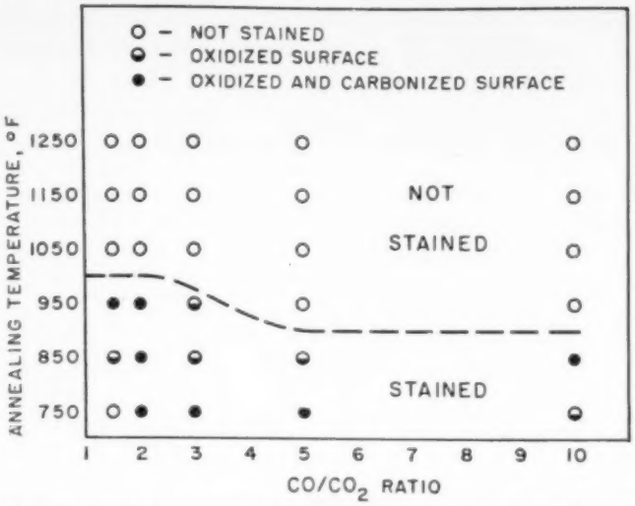


Figure 7 — Data shows effect of surface staining with exposure for 32 hr to DX gas of varying CO/CO_2 ratios.

is shown as a function of temperature and gas composition.

The encouraging results here call for more extensive studies, using other CO/CO_2 ratios, varying the H_2/H_2O ratio, and increasing the gas/steel surface ratio.

DISCUSSION OF RESULTS

The results of the annealing experiments with "snaky edge" samples indicate that the defect is very resistant to removal by DX gas. The implication that the stain may be formed on the heating cycle during annealing is borne out by the fact that iron oxides are readily erased by DX gas at 1285 F, and the corollary observation that characteristically, there is a bright deoxidized zone adjacent to the "snaky edge" zone.

Further, the location of the "snaky edge" at a short distance from the coil edge can be thought of as related to accessibility of the gas to an extent which is limited by the "feathering" of the strip edges during cold reduction. This proposition is substantiated by the observation that if a coil of cold rolled steel is accidentally struck on an edge prior to annealing so that a reverse fold is made in several wraps, the "snaky edge" then follows the contour of the dent, occasionally spreading out in a little pool of black deposit where the opening between wraps is greater.

The requirement that a temperature gradient is a probable prime factor in producing a "snaky edge" is met in commercial annealing by the very considerable temperature gradient between the edge and center of a coil during the heating cycle.

If it is postulated that the chemical reaction responsible for the formation of the "snaky edge" is

$$3Fe + 4CO \rightleftharpoons Fe_3O_4 + 4C,$$

the formation of a "snaky edge" can be conceived of as follows. During the heating cycle, at temperatures below 950 F (see Figure 7), DX gas reacts with the outer edges of the coil to the limit of accessibility and over the existing temperature gradient to produce only iron oxide on the hotter extreme edges of the coil, and iron oxide plus carbon in the next zone, ½ to 1 in. further in toward the center of the strip width. As the coil is heated further, the oxide in the outer zone is readily removed by reaction with the DX gas, while the black zone remains intact throughout all subsequent heating. Thus, these temperature-dependent chemical reactions account for the "snaky edge" anomaly of a bright deoxidized edge separated by a sharp line from a black deposit.

Because an iron surface must be available for reaction with the carbon monoxide, it is probable that an increase in the amount of iron surface by the presence of finely divided iron particles resulting from cold rolling will greatly accelerate the reaction producing "snaky edge." For this reason, steel rolls are greatly to be preferred for cold rolling to chilled iron rolls, because the latter produce large amounts of comminuted iron.

Another conclusion derivable from the foregoing hypothesis is that the reactivity of carbon monoxide may be controlled by keeping up the concentration of carbon dioxide. Since one of the reactions of the latter gas results in the formation of iron oxide by

$$3Fe + 4CO_2 \rightleftharpoons Fe_3O_4 + 4CO,$$

it would be desirable to prevent the overbalancing of the CO/CO_2 ratio by providing an alternative means of oxidizing the steel surface during the heating. This may be done either by increasing the percentage of carbon dioxide up to some selected temperature, such as 900 or 1000 F, and then shutting off the excess gas, by injecting steam at or near each annealing base during heating as above; or by simply not introducing the DX gas until after some oxidation has occurred.

SUMMARY

It is strongly indicated by the foregoing data that the "snaky edge" defect should be classified as an annealing defect, and that the place to look for its prevention is in control of the annealing operation itself. If carbon monoxide is the chief villain, then the CO/CO_2 ratio in the gas should be kept low. Sluggish gas flow in the furnace would also contribute to undesirable reaction during heating.

Practical recommendations for minimizing the occurrence of "snaky edges" should include lower CO/CO_2 ratio, higher header pressure to insure increased gas flow rate, and perhaps excess water vapor in the gas during the heating period. This could be handled by introducing excess CO_2 or steam, not at the DX generator, but near the individual bases, so that the DX composition may be returned to normal during the soak. It is also important to keep the gas composition in the latter period at a low CO/CO_2 ratio and at relatively low dewpoint.

ACKNOWLEDGMENT

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Part II

REACTION MECHANISM OF BLACK STAIN FORMATION ON ANNEALED STEEL COILS

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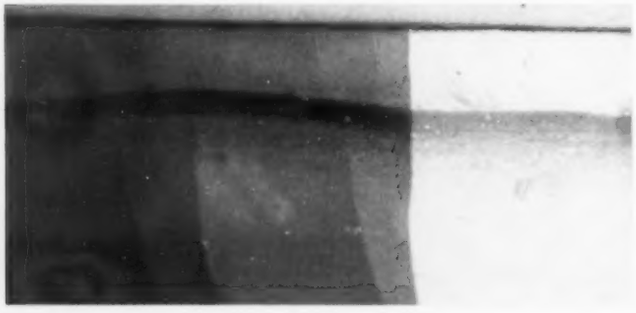
▲ STEEL coils annealed in DX gas atmospheres show a stain referred to as a black edge which is approximately ½ in. wide, and extends parallel to the edges of the interior of the coil approximately ½ in. from the edge (Figure 1). It was believed that formation of this edge is largely influenced by the DX gas which is composed of carbon monoxide, carbon dioxide, hydrogen, water vapor, methane and nitrogen. Individual components of this mixture can have an oxidizing, reducing, carburizing or decarburizing effect on steel depending on the temperature. In a temperature cycle from room temperature to 700 C (1292 F) to room temperature, a variety of complex reactions can occur between this mixture of gases and the steel. The complexity of the problem is further compounded by the difference in gas concentration in various parts of the interior of the coil owing to gas flow conditions and by the presence of a thin layer of rolling oil on the steel surface.

It was the purpose of this investigation to simulate formation of the black edge in the laboratory in order to study the influence of DX gas and of the rolling oil on this condition. The study was primarily divided into four parts: the effect of DX gas only on clean steel, the effect of rolling oil on steel in an inert atmosphere, the effect of DX gas and rolling oil together on the stain formation, and finally, the investigation of black edges obtained from steel mills by electron and X-ray diffraction. The influence of temperature, gas flow, and gap between steel sheets was investigated for each phase.

Figure 1 — Black edge on annealed steel is influenced by DX gas.



EXPERIMENTAL PROCEDURE

The low carbon steel sheets or strips used in these experiments were cut from a steel coil that had actually developed black edges after steel mill annealing. The surfaces of the specimens were sanded before the experiments in order to remove mill scale or pickle products. DX gas was prepared by mixing the pure components in the following percentage proportions: CO_2 5.5, H_2 10.5, CO 9.5, CH_4 0.39, N_2 74.2. A mass spectrograph analysis of the compressed gas mixture showed no other hydrocarbons or oxygen to be present. The gas was passed through a water saturator that was adjusted to a dew point of 5.6 C (42 F).

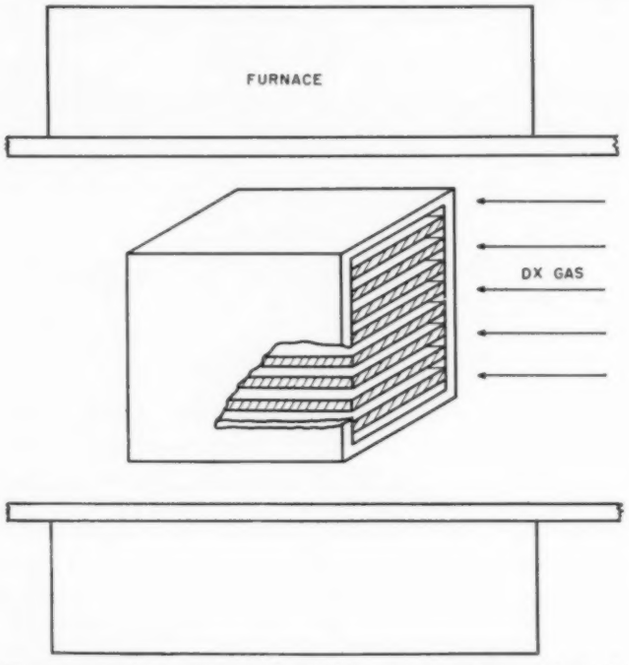


Figure 2 — Setup shows steel plates in experimental stack

The steel strips or sheets were placed in a vycor tube through which DX gas was passed at a flow rate of 1 liter per minute. A thermocouple in contact with the steel sample was used for the temperature control of the furnace. For the experiments in stacks, a steel box (Figure 2) which contained the steel plates separated by 0.02 in. was placed in the tube. The procedure generally consisted of purging the tube containing the steel sample with DX gas at room temperature, inserting the tube and sample into the pre-heated furnace, and observing the progress of the reaction at about 15-min intervals. The reaction could be satisfactorily stopped by switching from DX gas to purified argon. Preliminary experiments indicated that tank argon gas would cause staining of steel, therefore it was necessary to purify the argon gas by passing it through hot copper mesh, a phosphorus pentoxide drying tower, and hot steel wool.

Commercially available rolling oil was used for the experiments requiring an oil film on the steel surface. The oil film was formed by wiping the surface with oiled cotton. The amount of oil applied to the surface

was certainly excessive in comparison to the amount present on steel coils in the steel mill.

Although this method did not completely simulate the conditions of the steel coil annealing in the plant, it was felt that the results were indicative of the various effects of DX gas and rolling oil on steel.

RESULTS OF THE STAINING EXPERIMENTS

The DX gas mixture was found to form deposits even on clean glass surfaces in the absence of steel at temperatures slightly above 200 C (392 F). This was evidenced by the formation of a brownish and metallic gray product on the vycor tube near the point at which the cold gas entered the furnace.

DX gas with a flow rate of 1 liter per min began to react with clean single steel strips at temperatures above 200 C (392 F). An oxidation manifested itself first as a blue stain that was most intense at temperatures of 250 to 300 C (482 to 572 F), and which gradually became a light gray at 550 C (1022 F). At temperatures of 600 to 650 C (1112 to 1202 F), DX gas would neither stain clean steel nor readily reduce oxidized steel. Reduction of stained samples was observed at temperatures above 675 C (1247 F). As the temperature approached 800 C (1472 F) this reduction became quite rapid and samples that had been stained continuously for two hours were cleaned in 5 to 10 min.

DX gas was found to both stain and reduce steel strips in the direction of its flow. Staining or subsequent clean up did not start suddenly all over the exposed strip, but always started at the edge first in contact with DX gas. (An explanation of this effect is given later.) When directed on the center of a steel plate, DX gas produced heavy stains in concentric circles of different colors around the center. It should be emphasized that other flow rates and shapes of the specimens could produce different stains.

The size of the gap between two layers of steel is an important factor in determining the extent and appearance of the staining by DX gas. The experiments indicate that the gas penetration and subsequent staining is directly proportional to the distance between adjacent steel sheets. The existence of a gap between the steel sheets (Figure 3) not only limits the extent of staining but also influences the kind of stain produced. At 400 C (752 F) an individual steel strip stained a uniform light blue whereas steel sheets in a stack, i.e., separated by narrow spaces, also developed a black band stain some distance from the edge (Figure 3). No staining occurs at depths greater than ½ in. with a 0.02-in. gap.

In order to study the effects of rolling oil on steel at high temperatures, unoiled and oiled steel strips heated in a stream of purified argon were compared. Clean steel did not stain, but steel with an excessive amount of rolling oil developed black stains. At the same time oil condensates were observed on the cooler part of the reaction tube. The process in argon, therefore, consisted of a fractional distillation in which the black spots represent oil residues.

Oiled steel heated for two hours in DX gas develops, in addition to the previously discussed blue stains, a layer of black deposits. At temperatures above 700 C (1292 F), the blue DX gas stains are reduced, but in most cases the black stains persisted even if heated for a long period at 700 C (1292 F).

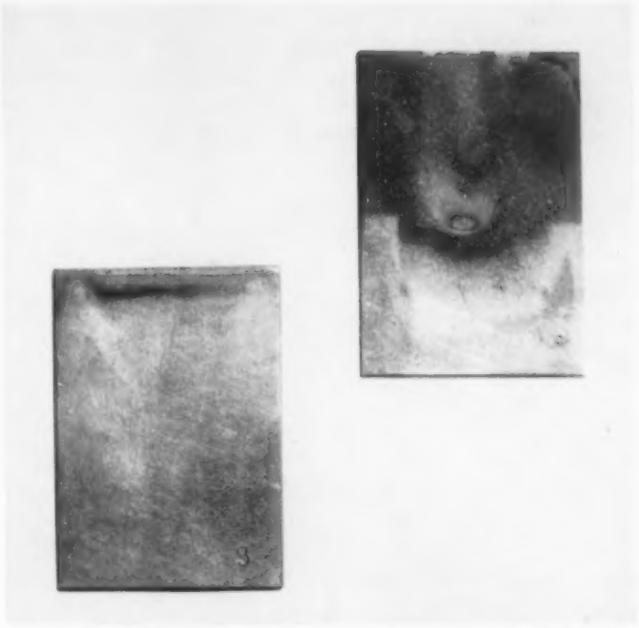


Figure 3 — Views show edge formation on stacked sheet in DX gas.

In order to more closely approach the conditions in the steel plant, long run annealing experiments were performed. Pairs of clean steel strips and oiled strips were heated for twenty hours to 700 C (1292 F), held for 20 hr at 700 C (1292 F) and cooled for 36 hr to room temperature. Heavy stains and deposits were found on both pairs. The differences between stains produced only by DX gas and those produced by DX gas and oil are not as pronounced for long term cycles as they are for the shorter period reactions. The major contribution to the visible black stain on the edge is made by DX gas decomposition and only excessive amounts of oil can alter the appearance of the stain.

The results show that staining under the above described experimental conditions is not in accordance with equilibrium calculations on the oxidation-reduction potential of the gas mixtures. According to Austin and Day[1]* carbon deposition and carburization will occur at low temperatures for a gas mixture having gas ratios of $CO/CO_2 = 1.7$ and $H_2/H_2O = 12$. But no oxidation effects should be possible below 750 C (1382 F). The occurrence of the blue oxide stains at temperatures between 220 to 500 C (428 to 932 F) can be caused by two different mechanisms. It is possible that a contamination by oxygen present in amounts below the limits of detection of the mass spectrograph analysis (0.05 per cent O_2) caused the staining. However, the formation of surface oxides of iron by purified CO and mixtures of CO and H_2 at low temperatures also was observed by Trillat and Oketani.[2] Using a flow rate of ten liters per hour of pure CO the iron oxides Fe_3O_4 and Fe_2O_3 were found to be present on iron foil after exposing it to the gas for three hours below 300 C (572 F). At higher temperatures increasing amounts of cementite Fe_3C, were formed together with Fe_3O_4, Fe_2O_3 and carbon. A mixture of CO and H_2 in a 1 to 1 proportion by volume produced only Fe_3O_4

* See Bibliography at end of paper.

up to 250 C (482 F). Above 350 C (662 F) Fe_2C, Fe_3C and graphite were found. It cannot be emphasized too strongly that the action of the gas atmosphere is determined largely by the flow rate of the gas, the shape of the work piece and the occurrence of dead spaces on its surface.

IDENTIFICATION OF BLACK EDGE COMPOUNDS

Steel sheets with black edges obtained from different steel mills were used to determine the chemical compounds on the surface. By wet chemical analysis of scrapings from the edge in one steel mill 34 to 45 per cent Fe, 22 to 30 per cent C and 0.5 to 2.7 per cent S were found. Samples from other mills did not contain sulphur. When single strips with black edges were exposed to DX gas at reducing temperatures of 750 C (1382 F) for one and two hours, the following results (Table I) were obtained. Black edges on some samples can be completely removed after a reducing heat treatment (No. 153). Some samples retain a silver gray appearance in the area of the former black edge. Of two samples taken a month apart (No. 142 and 146) from the same steel mill, only one (No. 142) could be completely reduced. The second showed black spots or black pitted areas after reduction in DX gas. These spots could not be removed even after a hydrogen treatment for two hr at 800 C (1472 F). The black edge of a steel sample from a third steel mill (No. 160) remained unchanged after reduction heating in DX gas at 750 C (1382 F). Differences in the reducibility of the black edge were found also in different parts of a long strip sample of the same coil (No. 146).

These experiments show clearly the existence of at least two different types of black edges on annealed steel sheets; black stains consisting primarily of oxides which can be reduced in DX gas and black edges containing more carbon deposits, which cannot be removed by reducing gas treatment. In order to identify the different compounds on the surface and in the steel underneath the deposits, 12 black edges obtained from steel mills were investigated by X-ray diffraction, electron diffraction and the electron microscope.

TABLE I

X-ray and Electron Diffraction of Steel Mill Annealed Coils

No.	Sample	X-rays	Electron diffraction	Black edge after reducing treatment in DX gas at 750 C (1382 F)
153	Bright outer edge	Fe	α-FeO.OH	
	Black edge	Fe	α-FeO.OH; C	removed
	Center of sheet	Fe	α-FeO.OH	
146	Bright outer edge	Fe	Fe; α-FeO.OH	
	Black edge	Fe	Fe; C	partly removed
	Scrapings of black edge	Fe	Fe_3O_4; C; Fe	
	Center of sheet	Fe	Fe; C; γ-FeO.OH (?)	
160	Bright outer edge	Fe	amorphous surface	
	Black and gray edge	Fe_3C; Fe	Fe, C, Fe_3O_4	not removed
	Center of sheet	Fe	Fe_3O_4	

Figure 4 — Electron micrograph at 12,000 X shows bright outer edge

Electron diffraction methods are suitable for the examination of the top surface layer of solids to a thickness from 50 to 3000 Angstroms (5×10^{-7} to 3×10^{-5} cm). Because of greater depth of penetration of X-rays in solid materials, thin layers of this order cannot be identified by X-ray diffraction. With X-rays however, the interior of the material is recorded on the diffraction diagrams. A combination of electron and X-ray diffraction methods applied to the same surface leads to information not only about the chemical nature, but also about the succession of layers and the approximate thickness of surface deposits. Most of the X-ray and electron diffraction data were obtained by surface reflection techniques. A record of the diffracted X-rays was obtained by the Geiger-Müller counter tracings of an X-ray diffractometer. The electron diffraction patterns were recorded on photographic plates. To identify the compounds, the position and intensities of the diffracted rays were compared with data published in the ASTM file cards.[3]

Black edges invariably contain one or more of the following substances: carbon, iron oxides like Fe_3O_4 and/or γ-Fe_2O_3, iron carbides like Fe_2C and Fe_3C and a variety of iron oxyhydrates like α-FeO.OH goethite or γ-FeO.OH, lepidocrocite. The oxyhydrates of iron frequently found on the sheet, must be considered as secondary reaction products of the steel sample exposed to the humid atmosphere. In few cases ferrous sulphides and noncrystalline carbon were found to be present on the surface.

In Table I the results are shown of the X-ray and electron diffraction measurements on three types of black edges. The data can be summarized as follows: DX gas reducible black edges are such that contain mostly iron oxides and almost no carbon (No. 153). Non reducible grayish stains and black edges are formed preferentially by carbon deposits on top of iron carbide in the sheet. An intermediate was found in black edge No. 146, where carbon but no carbides were detectable on the sheet. In Figures 4, 5 and 6, electron

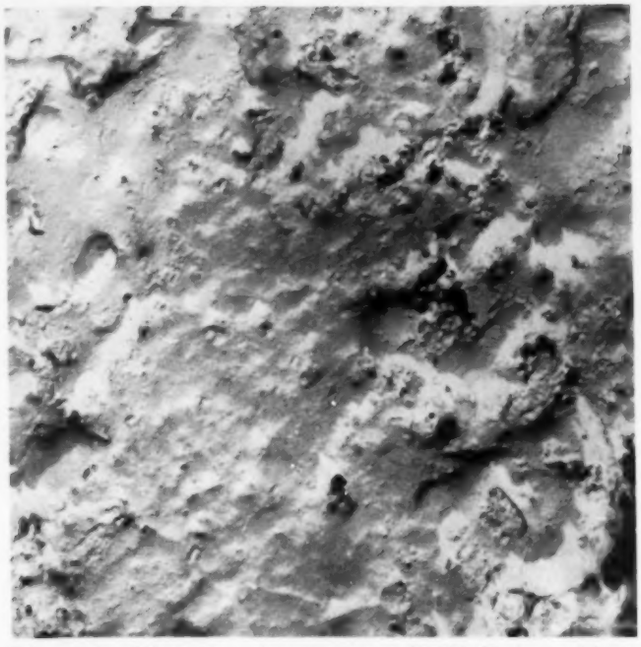


Figure 5 — Electron micrograph at 12,000 X shows black edge.

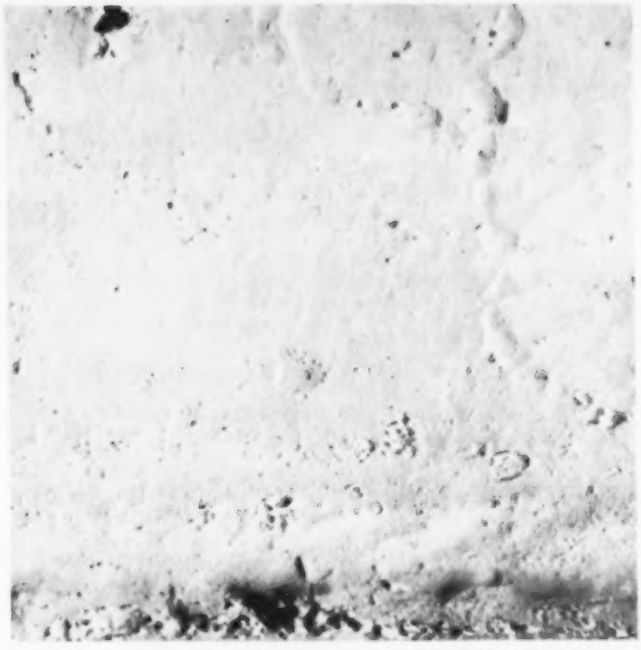


Figure 6 — Electron micrograph at 12,000 X shows center of sheet.

micrographs of replicas obtained at 12,000 X magnification are shown of the bright outer edge (Figure 4), the black edge (Figure 5) and the center of the sheet (Figure 6). The expected surface corrosion and etching by DX gas can easily be observed in the electron micrograph taken of the black edge area on the surface. Etched surfaces and deposition of carbon on polished steel by such annealing gas mixtures also were observed by A. L. Marshall.[4]

MECHANISM OF STAINING

A. *General considerations*—The conditions in steel annealing applications with a mixture such as DX gas are so complex even in the laboratory that they cannot be accurately postulated and, even more important, they cannot be accurately maintained in all parts of the annealing furnace. The difficulties in determining the mechanism of staining are increased by the very small amounts of oxides or carbon necessary to form a visible dark stain. Simple gas equilibria as determined on single pairs of gases (CO CO_2) are not applicable in the present case because of the stagnation and composition changes occurring in the gaps between the sheets. However, the observations made on different black edges by electron and X-ray diffraction revealed some details of the complex reaction mechanism. The sequence of substances found on the black edge of the sheets was iron, iron oxides and carbon, or iron, iron carbides, and carbon.

The question of the origin of the carbon deposits and carbide formation on the steel surface has two possible answers; carbon deposits can be formed by decomposition of CO from the annealing gas or by decomposition of oil on the surface of the sheet. Although it was found that oil vapors would contribute to the appearance of the stain, heavy carbon and oxide formation also can be observed if clean, oil free steel stacks are exposed to DX gas at elevated temperatures. In both cases the simplest reaction can be described by the reaction mechanism:

$$2\,CO \xrightarrow{\text{Fe catalyst}} CO_2 + C \qquad (1)$$

The catalytic decomposition of CO on iron, nickel, or cobalt surfaces takes place with high speed between 200 and 800 C (392 and 1472 F). Even in the absence of a metallic catalyst CO decomposes to a certain extent at elevated temperatures. Similar decomposition products on inert glass surfaces were observed by decomposition of DX gas at 200 C (392 F). In general when CO reacts with iron at temperatures below 225 C (437 F), carbides of iron are formed exclusively. Above this temperature free carbon deposition occurs.[5] At various higher temperatures these carbides undergo reactions, transitions and decomposition.[6,7]

$$3\,Fe + 2\,CO \rightleftarrows \underset{\text{cementite}}{Fe_3C} + CO_2 \qquad (2)$$

$$6\,Fe + 2\,CO \rightleftarrows 2\,Fe_3C + O_2 \qquad (3)$$

It was shown by Hofer, Cohn and Peebles[7] that hexagonal Fe_2C is the primary product of the reaction which decomposes above 300 C (572 F) into the Hägg carbide and at 500 C (1022 F) into Fe_3C and C according to

$$\text{hexag. } Fe_2C \xrightarrow[572\ F]{300\ C} \text{Hägg } Fe_2C \xrightarrow[1022\ F]{550\ C} Fe_3C \text{ cementite} + C \qquad (4)$$

Electron micrographs and X-ray examination of filamentry carbon formed by the interaction of CO and iron oxides in blast furnace brickwork[8] showed the presence of amorphous carbon, cementite Fe_3C and Hägg carbide Fe_2C. The catalyst in this case was postulated to be either iron or iron carbide formed on the surface of the oxide. The experiments of Royen and Blumrich[9] showed that there is a quick start of the reaction between CO and iron powder up to the formation of Fe_2C. By the time the surface is saturated with C (7.7 per cent C), the speed of the catalytic decomposition of CO decreases and solid C is deposited on top of Fe_2C. Other investigators[10,11] confirmed the

rapid carbiding and formation of the Hägg carbide at 275 to 325 C (527 to 617 F) but found the surface of iron catalysts sometimes completely covered with C before all iron is converted to Fe_2C. The cementite formed by heating Fe_2C (reaction 4) is quite stable and will stand many hours heating at 500 C (932 F) in a vacuum without decomposing. Possible interactions of surface oxides with the catalytic reaction of CO on Fe are not known.

The oxidation by CO_2 or CO can be described by the following reaction mechanisms:

$$3\ Fe + 4\ CO_2 \rightleftarrows Fe_3O_4 + 4\ CO \qquad (5)$$

$$3\ Fe_2C + 8\ CO_2 \rightleftarrows 2\ Fe_3O_4 + 3\ C + 8\ CO \qquad (6)$$

$$3\ Fe + 4\ CO \rightleftarrows Fe_3O_4 + 4\ C \qquad (7)$$

An investigation by Hall, DeWitt, Hofer and Anderson[12] indicates that the formation of the surface oxides does not proceed according to the reactions (5) and (6) but occurs by decomposition of CO according to (7). This reaction is believed to proceed at higher temperatures if insufficient CO supply is present.

B. *Gas stagnation and black edge formation with DX gas* —On single strip surfaces, oxide strains are formed primarily at low temperatures and readily removed at higher reducing temperatures when sufficient DX gas is available. In stacks of sheets or in coil annealing the

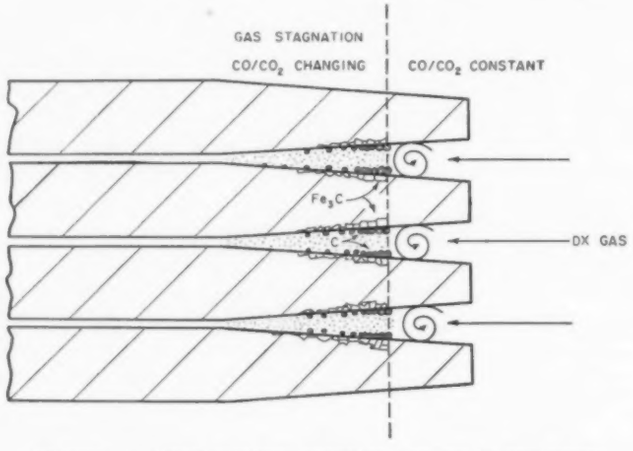


Figure 7 — Steel surface reactions occur in gas gaps.

conditions are different because of restricted gas flow in the gaps of the edges. The oxidation and reduction potential and the carburizing effect change with increasing distance from the outer edge. A temperature gradient between the edge and the center of the sheet contributes to the non-uniformity of the reactions. The conditions are best illustrated by Figure 7. To the right where sufficient and free DX gas flow prevails a constant ratio of $CO/CO_2 = 1.7$ will be maintained. The influence of the constant conditions reaches approximately ½ in. inside of the gap depending upon the gage, tightness of coil and time allowed for reaching an equilibrium. In this area equilibrium is reached and the normal oxidation and reduction phenomena occur.

To the left of the dashed line, however, capillary spaces exist between the sheets which restrict gas circulation. Gas eddies are formed and further penetration into the gap is only possible by gas diffusion. Changing pressures of the gases trapped in between the sheets (air, water and oil vapors) at the center of the coil will increase or decrease the penetration of the annealing gas into the gap if the temperature of the coil changes. The conditions in this space, therefore, depend upon uncontrollable gas exchange phenomena with continuously changing gas compositions in direction of the diffusion of the annealing gas. Most likely however, first a carburization according to reaction (2) and (3) takes place followed by an oxidation of the steel surface farther in the depth of the gap. After saturation of the surface with C and Fe_3C formation near the dashed line in Figure 7, carbon deposition starts by reaction (6). If unreacted iron surfaces are exposed to the stagnating gas, reaction (7) could form carbon and iron oxides. It should be emphasized that such reactions require a volume change which decreases the pressure above the reacting area until an equilibrium in gas pressure is reached.

The postulated reaction mechanism is in accordance with the appearance of sheets heated in stacks at low temperatures and with the simultaneous occurrence of oxides, carbides and carbon in black edges on steel mill samples. Sheets heated in stacks at low temperature show a black line (Figure 3) in some distance from the edge, and a blue oxide stain. Chemical tests and investigation by electron diffraction of the black stain and loose deposit formed on a single sheet by DX gas in two hours at 400 C (752 F) (upper right corner in Figure 3) showed the presence of amorphous carbon and Fe_3O_4. This stain was produced by directing a localized stream of preheated DX gas perpendicular to the steel surface. The changes in color and amount of deposit around the center of the stain indicate different reaction mechanisms in different sections of the stained surface.

In Figure 8 the first phase of a black stain formation is shown after heating the sheets in stack for three hours at 400 C (752 F). Two clean circular areas visible on the surface were caused by two screws used to hold the sheet in position inside of the annealing box (Figure 2). The two screws accidentally formed baffles for the diffusion of the gas into the gap. The black wavy carbon line, therefore, is determined by these baffles. On both sides of the black carbon deposits, blue oxide films are detectable following the same pattern. The appearance of this carbon-oxide stain can be explained as follows:

At low temperatures the stagnating DX gas first oxidizes the outer edge according to reactions 5 or 7.

$$3\ Fe + 4\ CO_2 \rightleftarrows Fe_3O_4 + 4\ CO \qquad (5)$$

This oxidation forms the observed blue stain and in the case of reaction (5) increases the CO/CO_2 ratio of the gas entering the gap between the sheets. An increase in CO subsequently leads to carbon deposition and carbide formation:

$$3\ Fe + 4\ CO \rightleftarrows Fe_3O_4 + 4\ C \qquad (7)$$

$$3\ Fe + 2\ CO \rightleftarrows Fe_3C + CO_2 \qquad (2)$$

$$6\ Fe + 2\ CO \rightleftarrows 2\ Fe_3C + O_2 \qquad (3)$$

$$2\ CO \xrightarrow[Fe,\ Fe_2C,\ Fe_3C,\ Fe_3O_4,\ (?)]{\text{catalysts}} CO_2 + C \qquad (1)$$

The reactions (1) and (7) form loosely adherent carbon

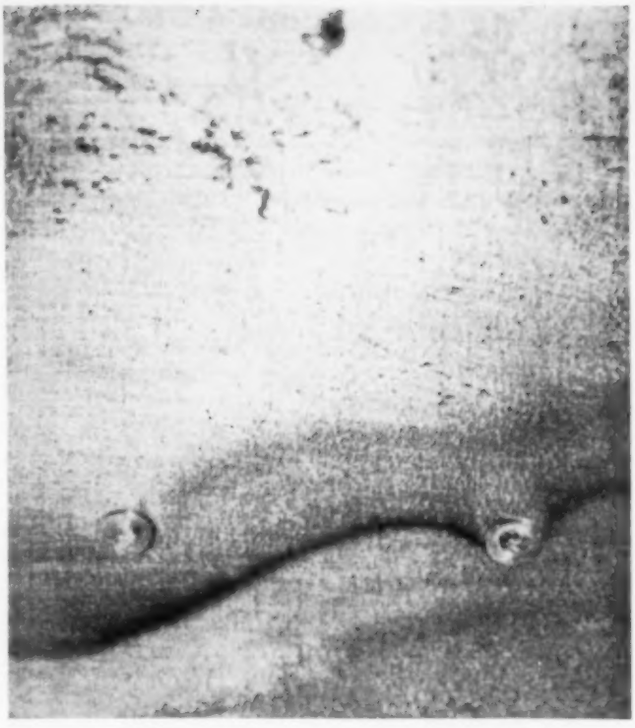


Figure 8 — Wavy carbon-oxide edge produced at 400 C (752 F) in DX gas.

deposits, which eventually can be wiped off from the surface.

Another carbon deposit can be formed by the decomposition of the carbides according to:

$$\text{hexagonal } Fe_2C \xrightarrow[572\ F]{300\ C} \text{Hägg } Fe_2C \xrightarrow[1022\ F]{500\ C} Fe_3C + C \quad (4)$$

$$2\ Fe_2C \rightarrow \alpha\text{-Fe} + Fe_3C + C$$

as postulated by Hofer, Cohn and Peebles, or by the reaction

$$3\ Fe_2C + 8\ CO_2 \rightleftarrows 2\ Fe_3O_4 + 8\ CO + 3\ C \quad (6)$$

The carbon, however, formed by decomposition of carbide grains, is imbedded primarily in the sheet surface and not removable. Both types of carbon formation were observed on steel mill and laboratory samples. Beyond the small area where the C deposition occurs, the reacting gas again reaches a higher oxidation potential because of CO_2 or O_2 formation according to the reactions (1), (2) and (3) and blue steel surfaces will be the result of this change of the gas composition in the gap. Blue oxide stains on both sides of the carbon line were observed in all cases where samples were heated in stack for a short time at 400 C (752 F) (Figure 8).

During the second phase of the annealing process in the steel mill predominantly reducing conditions exist, if the temperature of the sheet is raised to 700 C (1292 F). Because of large amounts of reducing gas available on the outer edge (see Figure 7) the existing low temperature oxide stain will be quickly removed. If there is sufficient time and gas supply for the diffusion of more reducing gas into the gap, the oxide stain on the other side of the carbon line in the gap will also be removed. The carbon deposit itself, however, cannot be altered by the reducing treatment so that a permanent carbon

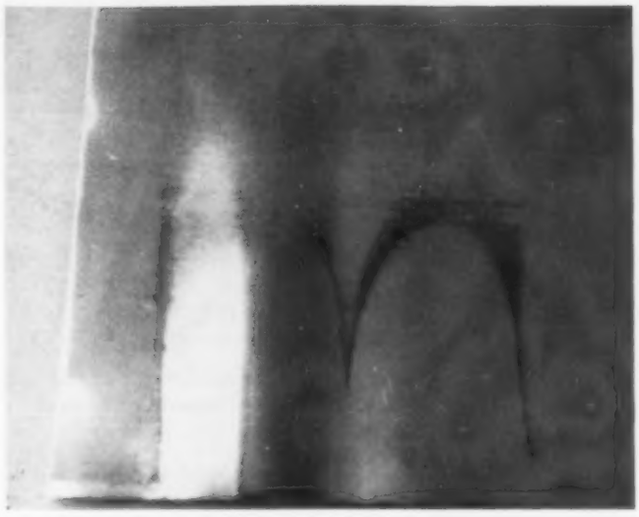


Figure 9 — Wavy edge of Sample No. 160 shows stain formation depends on access of DX gas.

stain remains on the surface (Figure 9). Insufficient supply of reducing gas inside of the gap at high temperature will result in a stain consisting of a carbon-oxide edge. The outer edge obtained will be bright. The final appearance of the edge after reducing treatment at high temperatures will be determined by the relative amounts of black oxides, carbon deposits and carburized iron.

Changing flow conditions of the annealing gas eddies formed in the furnace, changes of the pressure balance in the gap and changes in the width of the gap obviously will form an infinite number of unpredictable equilibrium conditions and therefore variations in the appearance or disappearance of the stain.

Coil annealing is, from the point of view of uniform heating[12] and reacting with the annealing gas, a metallurgical monstrosity. The difficulty in reproducing steel mill annealing conditions in the laboratory leaves no hope for a complete solution of the problem by small scale experiments. As in gas carburizing, however, the problem could be minimized if a judicious choice of flow rate and gas composition can be achieved during the annealing process of the coil.

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ACKNOWLEDGMENT

Acknowledgment is due to the sponsor of the work, Oil Products Company, Chicago, Illinois, for permission to publish this paper. The authors desire to thank Messrs. N. M. Adams and E. O. Strauss for their helpful discussions on the subject.

DISCUSSION

PRESENTED BY

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R. R. STRANGE, Cold Mill Metallurgist, Jones & Laughlin Steel Corp., Cleveland, Ohio

Sidney A. Paradee: The writers are to be congratulated on the presentation of a paper designed to clarify or at least identify a problem which has been a constant thorn in the side of cold reduction personnel for at least twenty years. It would be presumptious to attempt to enlarge on either the theory or the work of the authors.

I have no doubt that several reams of paper have been used in theories, corrective measures, and reports on this phenomena. I appreciate this opportunity to discuss my own personal experiences which may shed some further light on this problem. Our first siege was on tin plate production in 1937, and while it caused no trouble in subsequent cold reduction operations or temper rolling, it had one slight drawback, insofar as it ended up as waste waste. An immediate investigation was started. As years rolled on this was to be a regular procedure.

In the first one, we checked all the operations and discovered that over the weekend our mechanical department had forgotten to put the drip pans back on the tandem mill and consequently the screw-down lubricant was dropping on the sheet. Since the "gelling" medium in this grease was an insoluble lead stearate, this must have been the cause. We replaced the drip pans and made new ones to completely cover the top of the mill and, as you might have guessed, as soon as this material came out of the anneal, we were once more free of "carbon edges" or "snakes" as some people call them.

This Utopian condition lasted for six months and woe would have been unto the foreman who forgot to check the drip pans. All of a sudden trouble appeared again. This time the drip pans were in place. Since this occurred during a recession period in 1938, we were adequately staffed with extra foremen, so to keep them occupied we had them sitting in the office carefully cutting these areas out of sheets with hand tin snips.

After thereby concentrating the samples of the culprit, we were all prepared to make a chemical analysis. This was done with no definite results except that we did prove to have an excess of carbon in that area. This of course was interesting and proved conclusively that our eyesight was good. Someone then had the idea of adding a solution of phenolphthalein to some of the samples in a beaker and it turned purple. Now any high school chemistry student knows this can happen only where an alkali is present. Where did we have an alkali? Why in our washers, of course.

We soon discovered that our brushes wore out on the edges after washing narrow steel and when we widened out, we had excessive carryover. All we had to do was change brushes more often and maintain better control and we were out of trouble. This was done immediately and consequently there was no more trouble until the next time.

Since this had worked so successfully and we actually had conclusive proof of an alkali present rather than a theoretical stearate, for the next few years our washer foremen were taken to task at every recurrence.

Of course we did not give up on trying to duplicate this condition and we smeared coils with everything with which the steel could come in contact and a lot of things which only could have happened through sabotage. We were not successful. However, another peculiarity was noted; we had trouble only in the spring and fall. The logical solution was to shut down during May and October, but for some reason our customers insisted on deliveries in these months also.

In about 1942 after being in and out of his semi-annual trouble our washer foreman had an idea. Microstructures had been taken at 100 magnifications several times and showed nothing. He had some photomicrographs made at 500 and 1000 diameters and these showed a carbide formation apparent on the surface. Here was a new angle. Investigation of carburization indicated that this could be caused by the DX gas.

In retrospect and with excellent hindsight we wondered why we had not looked at our anneal before, but in checking with other mills they had no more success in discovering the answer than we had had.

Of course tying down a source and then healing the patient is another problem. We had to use a reducing atmosphere for bright plate so several studies were made, and it was discovered that this formation took place on the annealing cycle at somewhere between 750 and 1100 F. Grasping at straws we decided to increase the dew point of our DX gas. We figured the water gas reaction might act as a buffer to counteract this condition. It did and from this standpoint at least life became more liveable.

Needless to say the authors have proved that what we did the hard way was the proper answer at least as to the source. In tin plate production the advent of electrolytic tin and its edge, center, edge corrosion problem has necessitated the use of either NX or HNX gas which has practically eliminated the problem in tin plate production.

However, we now have another problem or the same one in a more complex form in sheet steel production. Here we can eliminate the washers because it is not washed. We then have oil on the strip so we evidently forget past history and the oil must be the culprit. Having switched my allegiance from the steel mill to the oil industry, I am still not naive enough to attempt to convince you that the oil has nothing to do with it.

However, the sponsor of this work at Armour Research Foundation, has evidently been accused of contributing to this condition much as I have been from

time to time. Dr. Schossberger's study, I believe, indicates that this phenomenon still is predominately from the gas.

As an added piece of information I will attempt to show what we found in taking Orsat analyses on three different bases, on steel rolled consecutively on the tandem mill, during the annealing cycle. Covers 1 and 2 were vented to 700 F and had compressed air added during this cycle and cover 3 was purged with DX gas to maintain a slightly higher concentration of this element.

An interesting analyses was made on the gas being vented from covers 1 and 2 before the DX gas was introduced. This showed: on cover 1 an analysis of 3.0 per cent CO_2 1 per cent illuminants, 0.7 per cent O_2, 2.2 per cent CO, 5.1 per cent H_2, 1.6 per cent CH_4, dew point 55 F, and on cover 2 to 4.0 per cent CO_2, 0.6 per cent illuminants, 1.0 per cent O_2, 1.7 per cent CO, 3.2 per cent H_2, 0.5 per cent CH_4, and a dew point of 55 F. This of course was the products of combustion of the oil on the strip.

As you can see from the analyses, the CO/CO_2 ratio changes considerably. In the case where the products of combustion or destructive distillation of the oil are allowed to remain in the cover, a very severe change, in the critical temperature range, is noted. The coils in cover 3 all contained carbon edge, the other two were free of it. The obvious conclusion is that oil can or might accelerate the formation of a carbon edge, but the gas reaction causes it. In the center of the sheet the residual oil will be apparent as a light dust. This is what the rolling oil can be blamed for and proper selection of a product which under destructive distillation in an inert atmosphere leaves a minimum of residue as indicated.

The solution of the carbon edge may be accomplished in two ways: (1) vent the inner covers and allow the oil vapors to escape while maintaining a dew point as high as practical without oxidation of the steel, or (2) change to a gas of such composition, such as NX, which will not cause carbon edges to form.

C. R. Lillie and D. W. Levinson: The authors wish to thank Mr. Paradee for his remarks, which are certainly welcome as substantiation of the major conclusions of the present paper: that the defects under discussion are due to annealing and that the temperature range of 750 to 1100 F is critical.

R. R. Strange. We would like to take this opportunity to compliment the authors of the foregoing reports for their excellent investigation into a subject that is very difficult to duplicate or predict on a laboratory basis due, of course, to the nature and scope of the actual operation of the annealing of cold rolled steel. They have pointed out innumerable reactions and conditions affecting the finished surface of annealed cold rolled steel that is of great interest to any producer conducting such an operation.

However, the surface defects mentioned in these reports are of a type that have been of small concern to our mill. First of all, when these conditions do occur, they cause very little difficulty since our plant does no terne plating, galvanizing, or lacquering. Secondly, our annealing operation has been such that we have encountered the aforementioned surface defects only rarely. For the most part, the surface defects that we encounter are of a type, i.e., blue steel, straw color, scale; that can be definitely traced to a significant equipment failure.

Our people feel that their success in producing bright surface steel is a result of: (1) Close adherence to the CO/CO_2 ratio that our combustion people have set for our operation which is about 1.9/1 and to a maximum dew point of 40 F, (2) Strict observance of a three hour minimum purge time, that is prior to light-up time and (3) Maintaining a constant gas pressure to our furnaces of two ounces pressure at all times.

In summary we point out that Cleveland Works of J&L is only rarely confronted with the type of defect described. However, the work presented in the papers is valuable to the understanding of the cold rolled process annealing operation.

C. R. Lillie and D. W. Levinson. Mr. Strange's comments have been read with interest by the authors. We were pleased to note that the operational procedure established at the Cleveland Works of J & L is in excellent agreement with the recommendations presented in the paper.

AISE Scholarship Awarded to Florida Boy

ROBERT LAW PORTER of Wauchula, Florida, has been awarded the Association of Iron and Steel Engineers Merit Scholarship in nationwide competition. Mr. Porter is planning on majoring in electrical engineering at the Georgia Institute of Technology.

This award is sponsored by the Association of Iron and Steel Engineers as part of the AISE program of educational activities which includes lecture courses, special publications and research work on selected subjects, and problems in steel plant engineering.

One AISE Merit Scholarship is awarded each year by the National Merit Scholarship Corp. who handles a nationwide competition to select outstanding and worthwhile youths for further education. Each merit scholarship awardee selects the school he prefers to attend.

The national merit scholarship program was begun in 1955. Last year the AISE awarded this same scholarship to Ralph D. Gray, Jr., of Killbuck, Ohio, who elected to study chemical engineering at Case Institute of Technology in Cleveland.

By DONALD R. MATHEWS

General Superintendent, Primary Production, Alan Wood Steel Co., Conshohocken, Pa.

AN AUTOMATIC

▲ALAN Wood Steel Co. is a small, fully integrated steel company with ore mines in New Jersey, and a plant in Conshohocken, Pa., where are located 151 coke ovens, two blast furnaces, open hearth, blooming mill, plate mill, hot and cold strip mills. In addition the company recently purchased a fabricating plant which manufactures lockers, shelving, etc.

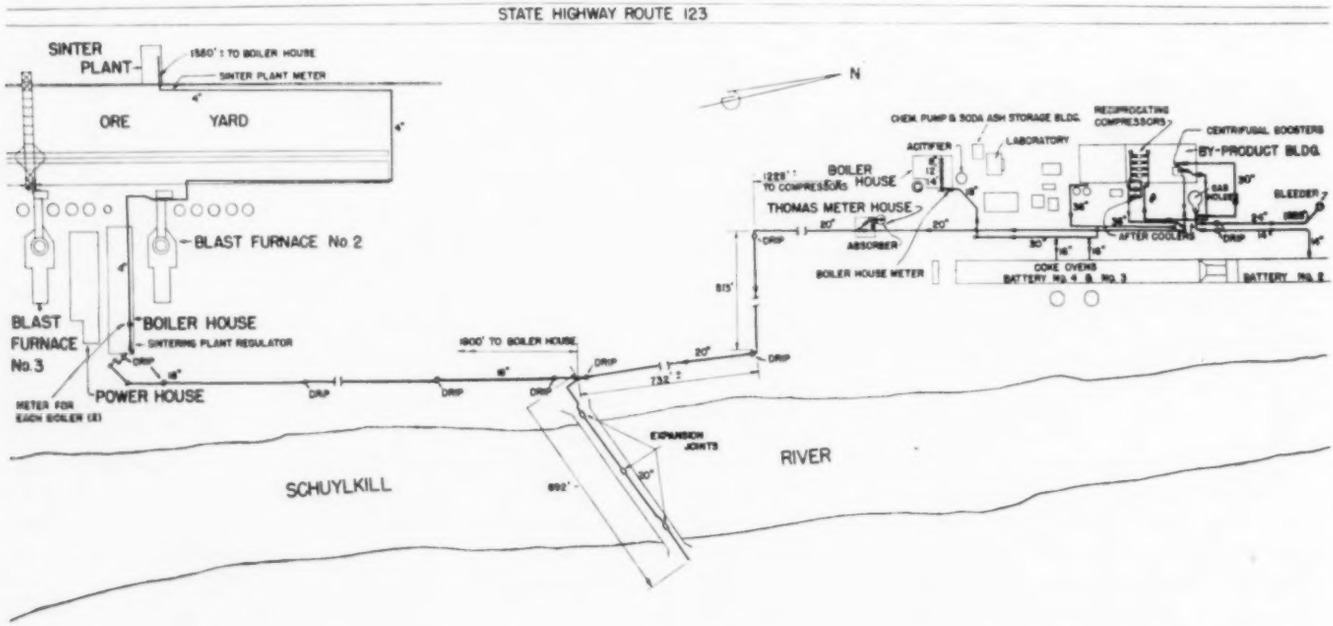
Normally about two-thirds of the coke ovens are used for the production of furnace coke, the remainder being occupied in the production of domestic and foundry grades. The ovens produce about 19,000,000 cu ft per day of coke oven gas. For many years most of the gas that was not used in heating coke ovens was sold to a local utility. The use of gas within the plant was normally held to a minimum, being limited to auxiliary heating such as in stopper rod ovens, drying of ladles and furnace spouts, and lighting of open hearth furnaces after rebuilding or extensive repairs. At times during the summers, which were the off seasons for the utility, their demand dropped off to the point where gas was used in soaking pits and occasionally it was necessary to burn 25,000 to 30,000 cfhr in several open hearth furnaces. Pressure of the gas at this time was never over 4 psi in the mains and frequently could be measured in ounces. Since this gas just floated lazily across the open hearth furnace combustion chamber closely underneath the roof brick, it would frequently be the cause of foaming heats that were very difficult to handle, thus damaging the roof brick because of overheating. For these reasons open hearth personnel considered its use a waste of fuel and a necessary nuisance.

Natural gas was made available to the utility in 1954 and the information that the contract, which terminated December 31, 1954, would not be renewed was received with a great many misgivings. Studies as to how this gas could best be utilized were started immediately. Several plants that were successfully using combinations of liquid and gaseous fuels were visited. (Our company is very grateful for the help received during these visits.) Many pointers were received that were extremely valuable in planning. From these studies, and information collected during visits to other plants, the following determinations gradually evolved:

1. Since the open hearth was by far the largest consumer of fuel, consisting of eight units which could normally absorb the wide fluctuations of available fuel, and operating 24 hours a day, seven days per week, the decision was made to use it as the dumping ground, or balance wheel, of the entire system.

2. The coke oven gas averages about 450 grains of sulphur per 100 cu ft. It would be impractical to live with the problems created by the use of such high sulphur fuel in the making of quality strip steel. A sodium carbonate desulphurizing plant, engineered for processing 16,000,000 cu ft per day of coke oven gas, and capable of reducing the sulphur content to 50, or less, grains per 100 cu ft would be installed.

Figure 1 — Gas flow through blast furnace and coke plant areas.



. . . after being forced into the use of coke oven gas for fuel in the open hearth, the installation of the automatic fuel control has resulted in making steel with lower fuel and rebuilding costs. . . .

SYSTEM OF FUEL CONTROL

3. The gas would be delivered to the open hearth at 20 psi line pressure.

4. The system would be completely automatic so as to eliminate the need for a gas distributing center and its attendant difficulties.

Figures 1 and 2 show a geographic gas flow diagram of the entire plant. This shows a small 20,000 cu ft gas holder and the connected bleeder, with igniter, that is capable of allowing all the gas generated in the system to escape and burn in the atmosphere in case of emergency.

The old boosters are in their original location. They consisted of one that was electrically driven and capable of pumping 24,000,000 cu ft per day @ 5 psi, and two that were steam driven and each able to pump 16,000,000 cu ft per day @ 4 psi. These boosters will pump the gas produced into the system at low pressure in case of emergency. This is the only part of the system that will not perform automatically. The changeover for them to pick up the load must be performed manually.

Next are the four reciprocating compressors, any three of which will carry the full load of gas produced. Pressure is controlled in two ways: 1. By means of a pressure relief valve, connected to the bleeder, on the high pressure side. This valve is set at 23 psi; and by position of the 20,000 cu ft gas holder.

As holder drops due to compressors pumping more gas than is being produced, eight limit switches that are spaced one foot apart along the vertical movement of the holder are successively activated, and load or

Figure 2 — Gas flow in rolling mill and open hearth areas.

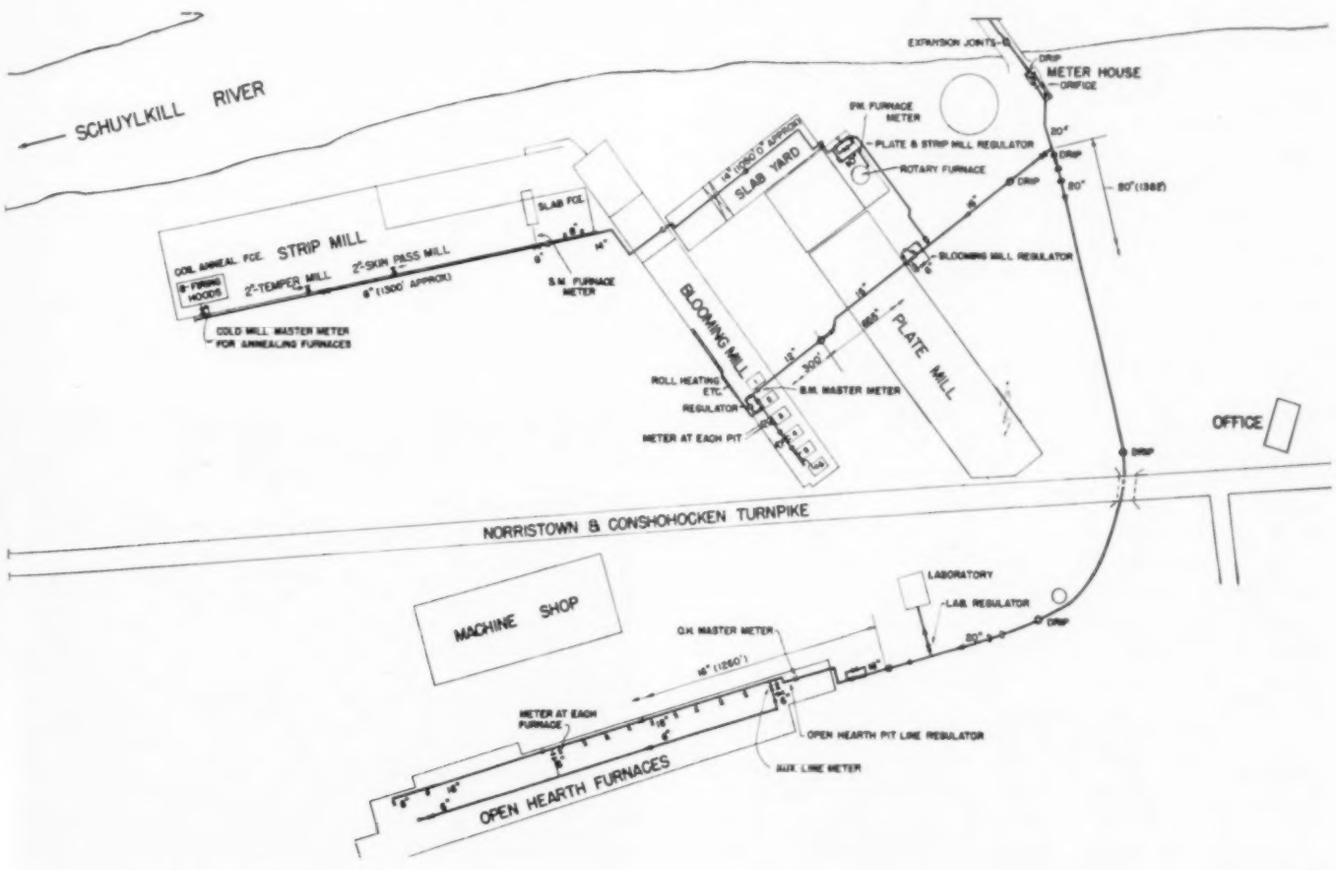


TABLE I
Compressor Loading Controlled by Holder Position
3 Compressors Running: 1-Compressor Spare

	No. 1	No. 2	No. 3	No. 4	Capacity, cfm	
	4/4	4/4	4/4	Spare	12/4	10,500
	Or spare	4/4	4/4	4/4	12/4	
No. 8	4/4	4/4	3/4	Spare	11/4	9625
	Or spare	4/4	3/4	3/4	10/4	8750
No. 7	3/4	3/4	3/4	Spare	9/4	7875
	Or spare	3/4	3/4	3/4	9/4	
No. 6	3/4	3/4	2/4	Spare	8/4	7000
	Or spare	3/4	2/4	2/4	7/4	6125
No. 5	2/4	2/4	2/4	Spare	6/4	5250
	Or spare	2/4	2/4	2/4	6/4	
No. 4	2/4	2/4	1/4	Spare	5/4	4375
	Or spare	2/4	1/4	1/4	4/4	3500
No. 3	1/4	1/4	1/4	Spare	3/4	2625
	Or spare	1/4	1/4	1/4	3/4	
No. 2	1/4	1/4	0	Spare	2/4	1750
	Or spare	1/4	0	0	1/4	875
No. 1	0	0	0	Spare	0	0
	Or spare	0	0	0	0	0

unload the compressors by stages, thus controlling the amount of gas pumped (Table I). If the compressors fail for any reason, gas is released through the bleeder, and an audible alarm signifies that the standby boosters should be started.

Air operated pressure regulators are installed at all branch outlets from the main line: the coke plant boiler house, the blast furnace, the plate mill, strip mill, and soaking pits, the chemical laboratory, and the open hearth auxiliary line. These regulators are all set at 5 psi. The open hearth main is the only line that operates at the higher pressure.

Meters are placed at strategic locations so that the total gas used by any department is metered. Then, of course, there are meters for individual units within the various departments.

The actifier and scrubbing towers of the desulphurizing unit are located beside the coke plant boiler house. The question might logically be asked as to why the compressors and the desulphurizing unit were not placed at the open hearth since that is the only portion of the system that really needs the high pressure and low sulphur fuel? There were several reasons: first, there was an attendant at the by-products plant who could be used to take care of the new equipment since he would no longer have to take care of the boosters; second, if placed at the open hearth the old booster system would have to be kept in service to move the gas over to the compressors and there was some doubt as to whether another booster would not be needed in order to insure pressure in the low pressure lines for the other departments. In addition it would have been necessary to spend $20,000 for a new rotor for one of the boosters. Also the problem of getting rid of the foul gases from the desulphurizing unit, which are now being burned under the boilers at the coke plant, would have been much more difficult.

Up to this point all the available excess coke oven gas that is not removed from the system through any of the branch outlets is delivered to the open hearth main with most of the sulphur removed and at approximately 20-psi line pressure. The problem then was to develop an open hearth control system that would, under normal operating conditions, automatically utilize the fuel without permitting waste by bleeding to the atmosphere at the pumping station. Instrument manufacturers were called in and asked to work to the following specifications:

Individual furnaces to automatically start using gas at different and predetermined line pressures.

Furnace controls to deliver any amount of fuel from 0 to 600 gphr fuel oil equivalent as demanded by the operator. This demand, reading in gphr of oil, to be accomplished by the setting of one hand wheel.

Provide an adjustable set-point device to permit variation in percentage demand of coke oven gas to total fuel. This demand to be satisfied automatically when gas is available.

Minimum gas flow to start at a line pressure two psi below the predetermined setting for an individual furnace, and increase with line pressure until the percentage demand is satisfied at the predetermined set-point.

Liquid fuel to automatically cut back as gas comes on.

Liquid fuel to never get below a given flow on automatic firing.

Steam flow to vary with liquid fuel. Ability to bias this flow so that the proportion of steam to oil increases as the flow of oil decreases.

Time delays to be incorporated in fuel controls so that cycling would not be caused by temporary line pressure fluctuations occasioned by other furnace reversals.

Combustion air to vary with total fuel fired.

All controls to record and indicate. Gas controls also to integrate.

Complete manual controls to be provided in case the automatic should fail, or if required for other reasons.

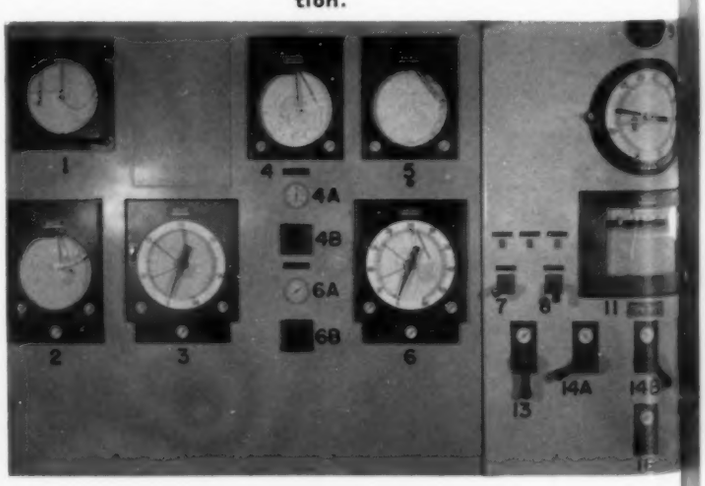
Automatic reversal, controlled either by time or checker temperature, and with steam, air and fuel cutting off and coming back on in proper sequence.

Audible warning that reversal is about to take place.

Suitable metering so that the amount of fuel used by individual units could be determined.

Figure 3 shows panel boards as they are now. Before automation, there were indicating and recording instruments for fuel flow, roof temperature, furnace pressure, and three of the furnaces were equipped with four point recording instruments which recorded the temperature of the top row of checker brick in each

Figure 3 — Panel boards are arranged for convenient operation.



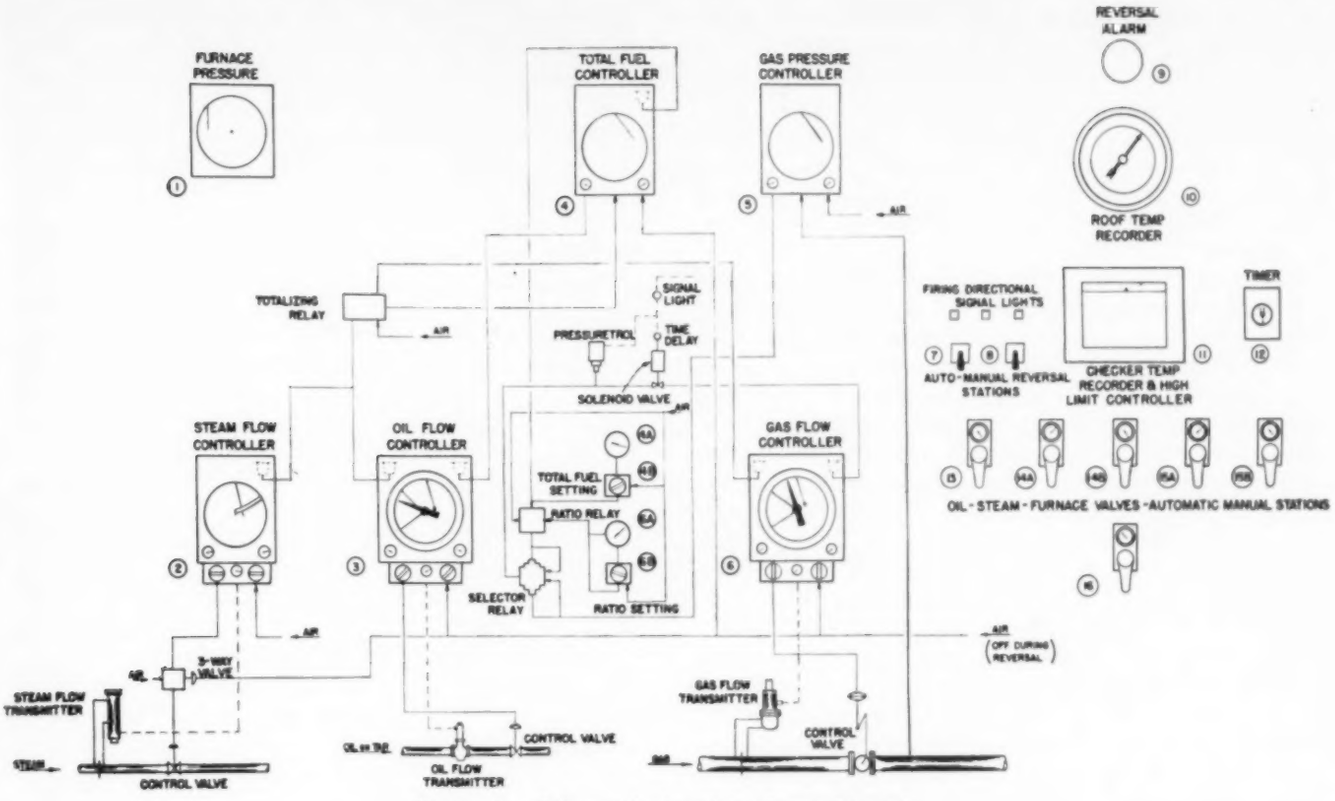


Figure 4 — Schematic drawing of panel board.

of the four checker chambers as determined by radiation measuring units. These instruments have all been tied in with the automatic system.

These instruments can all be identified in the schematic drawing.

The fuel control system is set up to burn coke oven gas at a preset rate plus liquid fuel as required to satisfy the total fuel demand. If the total fuel demand decreases below the setting of the coke oven gas demand signal, the coke oven gas will automatically cut back to maintain a minimum liquid fuel flow to the burners. If the pressure of the coke oven gas falls below some critical value, or the coke oven demand signal decreases below a minimum point, the flow of the gas to the burners is shut off completely and the total fuel demand must be satisfied by liquid fuel alone.

Figure 4 shows a schematic drawing of panel board. The total fuel demand is established by adjusting a 3 to 15-psi pneumatic signal at the manual loading station (*total fuel setting-4B*). This signal is indicated on the dial (*4A*) and transmitted to a *total fuel controller* (*4*), as well as to one side of a *selector relay* through a *ratio relay*. The setting of the *ratio relay* is established by adjusting a 3 to 15-psi pneumatic signal at the *ratio setting* (*6B*). This signal is indicated on the dial (*6A*) and shows the maximum percentage of the total fuel that will be coke oven gas if it is available.

The use of coke oven gas in each furnace is governed by the *gas pressure controller* (*5*). This instrument detects the proper line pressure when gas is available and transmits a pneumatic signal to the other side of the *selector relay*. The *selector relay* sends along the lower of the two signals to the control index of the *gas flow controller* (*6*).

When gas is available, as determined by the setting of the demand hand on the *gas pressure controller*, the *ratio relay* portion of the system comes into play. The *pressure controller* energizes a signal light indicating that gas is available and at the same time energizes a solenoid valve to remain in the open position and allow control air to flow to the control index of the *gas flow controller*. The *gas flow controller* pen is driven upscale and the gas valve is opened due to its air to open action. If the gas requirement, or availability, falls below a predetermined low level, the solenoid valve is deenergized by the pressure control and control air is shut off from the *gas flow controller* thereby cutting off the flow of gas. A *time delay* has been incorporated in the system to prevent gas from cycling off and on due to sudden changes in pressure from any cause.

The *gas pressure controller* continuously records and indicates line pressure of coke oven gas. The set-point feature of this instrument is particularly valuable to supervision. By setting the demand hand on all instruments at ¼-psi graduations, maximum gas usage can be directed to the individual units as desired. This tends to eliminate some cycling of gas on individual furnaces and to level out the pressure in the gas main.

The *gas flow controller* records, indicates, and integrates gas flow, controls it in accordance with the setting of the *ratio relay*, and in addition transmits a pneumatic signal to a totalizing relay. The totalizing relay gets a similar signal from the *oil flow controller* (*3*), adds them together and transmits the sum to the *total free controller*. Any discrepancy between this sum and the total fuel demand, as determined by the set-point of the *total fuel setting*, is detected by the *total fuel controller* and it, in turn, transmits a pneumatic signal to the *oil flow controller* causing it to make up the deficiency with liquid fuel.

The *oil flow controller* records and indicates. If coke

oven gas is not available, the full pneumatic signal from the *total fuel controller*, as determined by the *total fuel setting*, is transmitted to it thus causing the entire fuel demand to be satisfied with liquid fuel. Even with full gas availability a certain percentage of liquid fuel is required to obtain good flame characteristics. The *ratio relay* is set so that, when firing automatically, oil flow will not fall below a given rate. In our case this is 100 gphr.

The *total fuel controller* records and indicates.

The *steam flow controller*, which also records and indicates, is interlocked with the *oil flow controller* so that the steam flow varies with the flow of liquid fuel. This instrument can be biased so that the proportion of steam to oil can be automatically regulated at all rates of flow.

The signal from the totalizing relay can be used to control combustion air. While this drawing does not show it, one furnace is equipped with an *air flow controller*. It controls the amount of air entering the checkers by means of vanes in the inlet to the combustion air fan.

The signal from a furnace *pressure recorder* (*1*) can be utilized to control furnace pressure in a like manner. This is also being done on one furnace and is accomplished by controlling the amount of air entering the ejection air fan. It is almost a foregone conclusion that others will be equipped with both *air flow controller* and *pressure controller* in the near future.

The *steam flow controller*, the *oil flow controller*, and the *gas flow controller* may individually be changed over to manual control by means of the buttons located in the lower left hand corner of the instrument. After being set on "Manual," the flow is controlled with the button in the lower right hand corner. It is well to note, however, that if the liquid fuel controller is set on manual the system will not work because the liquid fuel always makes up the difference between total fuel demand and the flow of coke oven gas. The proportion of steam to oil for different rates of oil flow can be biased by changing an adjustment behind the hinged face.

All fuel recording instruments are graduated in gallons of oil per hour equivalent.

Item (*7*) is a switch for changing reversals from automatic to manual control.

Item (*8*) is the reversal switch to be used when (*7*) is set for manual control. These reversal switches are normally set for automatic control, and are changed to manual only when the operator wants to run everything on the board automatically except reversals. The small signal lights above show green when firing on one end, red when firing on the other end, and amber when a reversal is taking place.

Item (*9*) is a horn that gives audible warning that a reversal is about to take place.

Item (*10*) is a roof temperature indicator and recorder. It is actuated by a radiation pyrometer aimed at a point about three feet from the backwall opposite the middle door, and is used only as a guide for the first helper since it does not control fuel input. We experimented with such controls several years ago but discontinued their use because they were continually shutting the fuel off at critical moments in the making of a heat.

Item (*11*) is an instrument that records the temperature of the top row of bricks in each checker chamber as previously mentioned. This is a means of preventing a checker from becoming too hot. When the temperature in the checkers in the outgoing end reaches an adjustable set-point in the instrument, the furnace will reverse regardless of whether the time interval, as indicated by the reversal timer set point, has passed or not. It may also be used to "balance" the checkers in opposite ends of the furnace. To illustrate: suppose the timer is set for 10-min reversals but one end is running 200 degrees less temperature than the other. The control set-point may be adjusted to a point below the maximum temperature attained in the 10-min period on the hot end, thus causing the furnace to reverse in 8 min when firing in this direction. Upon reversing, the furnace will fire for the full 10 min because the temperature on the cool end does not reach the set point.

Item (*12*) is the above mentioned timer control for reversals. It can be varied from 0 to 30 min.

Item (*13*) is a liquid fuel off/on control.

Items (*14A*) and (*14B*) are steam controls for the burners in the two different ends of the furnace. They are normally set for automatic control and are moved only when it is desirable, or necessary, to reverse steam flow manually, or shut it off completely. Items (*15A*) and (*15B*) are fuel controls of the same type.

A reversal cycle is started when an electric circuit is closed, either by the timer or by the checker temperature recorder with high temperature contact. The current, via a latch-in relay, lights an amber light that stays lit during the reversal cycle, causes an alarm horn to blow, and starts a motor thus rotating the camshaft of a program controller. The program controller, in turn, operates through pilot valves activated by ten cams "A" through "J" (not shown in Figure 4) on the rotating shaft.

The medium of control is compressed air at a pressure of 45 to 50 psi.

Cam "A" sets the time delay relay that determines the length of a reversal cycle.

Cam "B" operates signal lights that indicate which end of the furnace is under fire. Indicator lights show green for one end and red for the other.

Cam "C" resets the timer back to zero.

Cam "D" operates dampers and/or air gates for reversal of air through the furnace. This cam may be used either for furnaces that are reversed by means of electricity or those that are reversed by means of hydraulic rams. In the first instance, the pneumatic signal generated by the pilot valve is transmitted to an air pressure switch which activates the switchboard that reverses the damper controls. A 30-psi signal sets dampers for firing on one end and a 0 psi signal sets them for firing on the other end. In the second instance the generated signal is transmitted directly to the loading head of a three-way air pilot valve installed in the loading signal line of two receiving regulators. The receiving regulators are used as reversing valve operators by mechanically linking them to hydraulic control levers. A 30-psi signal to the air pilot valve causes dampers on one end of the furnace to move up while those on the opposite end go down. A 0 psi signal reverses the process. The receiving regulators may also be set manually.

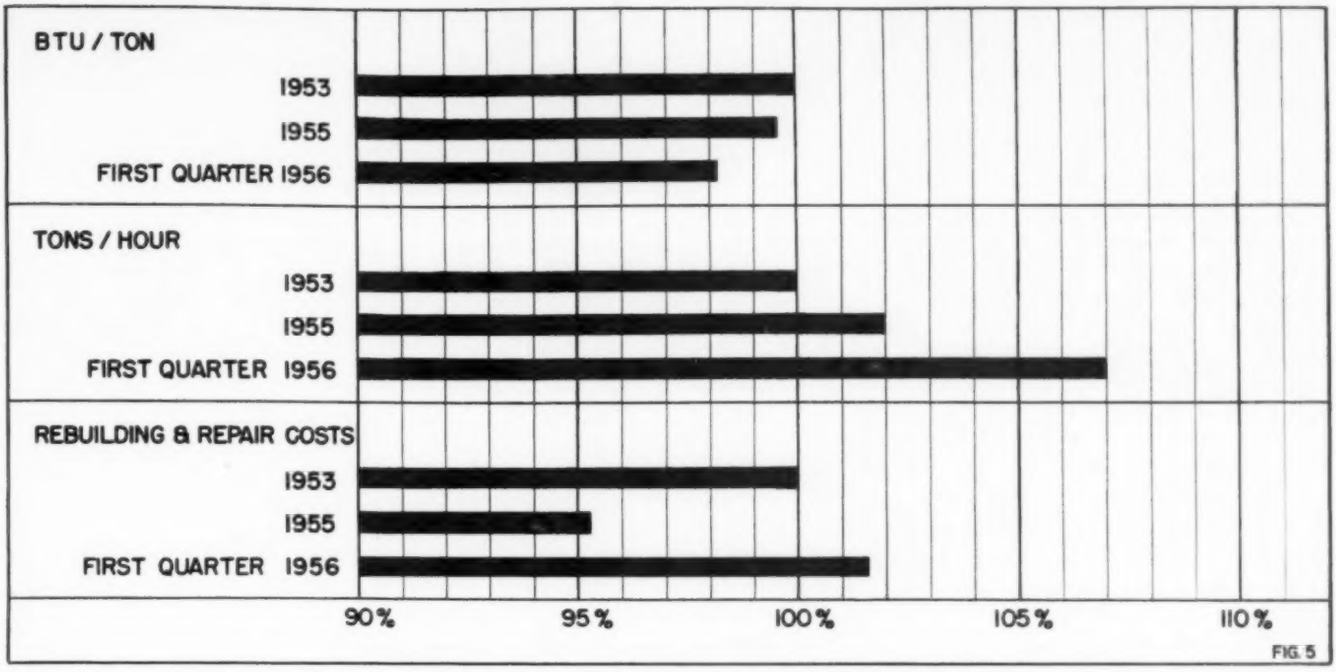


Figure 5 — Comparison of operations before and after setting up automatic controls.

Cam "E" controls fuel shutoff valves in the mains and locks the combustion air fan inlet vane control during reversal on the one furnace so equipped.

Cams "F" and "G" open and close fuel shutoff valves immediately ahead of the burners at opposite ends of the furnace. In this case a 0 psi signal on pilot valves on one end causes oil and gas to come on while a 30-psi signal shuts it off.

Cams "H" and "I" control the flow of atomizing steam to the burners on opposite ends of the furnace in the same manner as the fuel is controlled.

Shutoff valves are of the diaphragm operated type and installed in the supply lines to the individual burners. These valves are opened on a 30-psi signal and closed on a 0 psi signal. The corresponding air pilot valves are so set up that a 0 psi signal causes a 30-psi signal to be imposed on the loading head of the shutoff valve.

Cam "J" is used for locking the ejection air fan inlet vane control in position during reversals. In this case a 0 psi signal locks the control and a 30-psi signal restores it to automatic operation.

Three position manual control valves are installed in the loading signal line from each of the cam operated pilot valves. These may be used to interrupt the automatic signals generated by the program controller, thus providing a means of manual control.

This system has worked out very well for us. It is a little difficult to educate the average first helper to use the controls properly, but the effort is well worthwhile.

All the operator has to do is to be sure that all instruments are set for automatic control, set the total fuel controller for the number of gallons of oil he wishes to burn per hour, and the percentage of the total fuel he desires to be gas, then put the fuel control to the "on" position. From that point on he is free to observe his heat, watch roof temperature, take care of his flushhole or any of his other duties (even go get a cup of coffee), and he can rest assured that his furnace will be reversed at regular intervals, that the proper amount of fuel will be fired, and that coke oven gas will be used if it is available for his furnace. A simple flick of the wrist will change reversals from automatic to manual, but the fuel, steam, and air will remain on automatic control. If he desires he can change fuel, steam, and air to manual and permit the furnace to reverse automatically. Almost any combination of automatic and/or manual may be set up on the board.

Furnaces may be operated during a power failure by bypassing the normal controls. Any furnace equipped with an ejector air fan will only limp along at drastically reduced firing rates because natural draft is insufficient. Recording instruments will not show rate of flow.

However, if there is an air failure, most furnaces must shut down completely due to the fact that there is no way to reverse. The exceptions are furnaces that can be reversed electrically. Compressed air is a necessity for automatic control.

Many people will tell you that furnaces can be reversed just as fast manually as they can be automatically. This may or may not be true, but how many of them actually are?

A study in any shop will reveal that the fuel is off roughly twice as long when reversing manually as when reversing automatically. In addition, manual reversals are much more erratic than automatic and one can set up for shorter reversal periods on automatic than could possibly be expected of any man reversing manually. Shorter reversal periods means higher average temperature of combustion air and, therefore, higher production rates. Regular reversals also mean less damage to refractories, particularly in slag pocket and checker areas.

Supervision has a complete and continuous record of the operation of each furnace daily.

Foremen and first helpers can tell at a glance whether a furnace is functioning properly if they know how to read the panel board.

Complete metering of fuels takes much of the guess-

work out of apportioning fuel costs in the accounting department.

The combination gas-oil flame is more efficient than straight oil, particularly when the combustion chamber is comparatively cool. The flame is more luminous than any we have ever been able to develop with straight oil.

Our company was driven to taking a step that has proven very beneficial to us in the open hearth department. More steel is being made with less fuel and lower rebuilding costs than ever before.

1955 was the first full year of operation with complete automatic fuel control. The bar graph (Figure 5) compares 1955, and the first quarter of 1956, with 1953 which was the last full year of capacity operation without automatic control. Other conditions, such as percentage of hot metal, were very much the same.

This graph also shows changes in rebuilding and repair costs, fuel used per ton of steel made, and tons per hour tap to tap, using 1953 as a base of 100 per cent.

The accounting department reports that labor and material costs increased 8.3 and 14.8 per cent respectively when comparing 1955 with 1953. In spite of these increased material and labor costs, the graph shows rebuilding and repair costs for 1955 were only 95.3 per cent of 1953. During the first quarter of 1956 this has increased to 101.1 per cent of 1953. However, it is still a nice savings if adjusted for increased material and labor.

The graph also indicates that fuel used per ton in 1955 was 99.6 per cent of 1953, and in the first quarter of 1956 was 98.2 per cent of 1953.

Production for 1955 was 102 per cent of 1953 and for the first quarter of 1956 was 107 per cent of 1953.

Finally automation is not an answer to all the operators problems. It is suggested that it is a valuable tool to aid in doing the best job possible with the equipment one is asked to operate.

DISCUSSION

PRESENTED BY

F. E. STEPHENS, Assistant Superintendent Combustion Engineering, Republic Steel Corp., Cleveland, Ohio

DONALD R. MATHEWS, General Superintendent, Primary Production, Alan Wood Steel Co., Conshohocken, Pa.

HOWARD L. HALSTED, Assistant Fuel Engineer, Bethlehem Steel Co., Sparrows Point, Md.

F. E. Stephens: We all realize that automatic controls alone will not cause successful operation of a program of burning gas in open hearths. Mr. Mathews says the gas is delivered in the open hearth lines at 20 psi. I would like to ask what pressure is used at the heel of the burner, since that affects the velocity of gas that goes into the furnace and is burned?

Is there anything of special note in the form of the burner, that is, in the fuel atomizer and the space relationship of the delivery nozzles for gas and oil?

Donald R. Matthews: In answer to your first question, the pressure at the burner varies from about 9 to 12 psi depending on the exact line pressure in the main.

On the second question, gases are introduced through a 2 1/2-in. opening. It comes in over the top of the 3/4-in. fuel oil line.

Howard L. Halstead: Our experience at Sparrows Point in using coke oven gas as an open hearth fuel parallels that at Alan Wood in that the extensive use of gas in the open hearth was prompted by the loss of the Baltimore Gas and Electric Co. as an outlet for surplus gas. The changeover from manufactured to natural gas by the local utility and our resulting use of large quantities of coke oven gas occurred in 1950.

At that time our open hearth furnaces were equipped with the usual complement of instruments and controls necessary for burning a single liquid fuel. To accommodate the changeover to dual fuels—liquid and gas—a gas flow meter, gas flow controller, and automatic gas reversing valves were added to the existing equipment.

Unlike Alan Wood, our furnaces are not normally operated with automatic cutback of coke oven gas from line pressure. In fact, our initial success with coke oven gas as an open hearth fuel certainly resulted in a large measure from the premise taken by our operating people that gas should be burned in amounts dictated by the requirements for good furnace operations, and not by gas availability.

Our open hearth shops do, however, follow long cycle changes in gas availability by varying the number of furnaces operating on dual fuels. However, automatic dispatching of coke oven gas from changes in line pressure is done on several of our large reheating furnaces. The equipment used on these furnaces is similar in principle to that described in Mr. Mathews' paper.

We made the changeover with no change to basic instrumentation and controls on the furnaces. The only change was from the use of 100 per cent liquid fuel to the combination firing of 60 to 65 per cent gas and the balance bunker C fuel oil. After such changeover, our furnace production rates were essentially the same as the production rates maintained with 100 per cent fuel oil firing. Our unit fuel rates, however, increased about 10 per cent per ton of steel made.

Donald R. Mathews: I would just like to remark that Bethlehem Steel Co. is one of the companies we are very much indebted to for advance information concerning the use of liquid and gaseous fuels.

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

Conversion of Automotive and Industrial Engines to LIQUEFIED PETROLEUM GAS

By
P. F. Walker
Mechanical Engineer
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Bethlehem Steel Co.
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▲ A great deal of interest in LPG (liquefied petroleum gas) as a motor fuel has been generating within industry in the East during the past year. This is due principally to the recent promotion of LPG by eastern refiners and petroleum marketers who now have a reasonable supply of this product to sell.

The use of liquefied petroleum gas as a motor fuel is certainly no longer in the experimental stage as evidenced by the rather large installations in the midwest, west and southwest which have been operating successfully for as long as twenty years. In 1955 approximately 670,000,000 gal of LPG were consumed as motor fuel and carburetion sales were up 87 per cent over 1954. The growth of prospective motor fuel usage of LPG in the east is almost coincident with the increasing production of eastern refineries and the projected delivery of pipe-line propane to the New York area in the near future. Undoubtedly this pipe-line propane from the oil fields will be marketed at still lower prices than those prevailing in the eastern districts at this time. Therefore, if anything, the price differential between high-grade gasolines and LPG should widen, particularly since informed sources believe that production costs incurred in making improved higher octane gasoline fuels will be proportionally higher than the improvement in the fuel product. It would, therefore, appear that the future for motor fuel application of LPG from the economic and availability viewpoints should be exceptionally good.

In order to provide the necessary background for our main topic of discussion, that of the conversion of automotive and industrial engines to propane or LPG, we will briefly review some of the basic facts relative to the LPG fuel itself. First of all, the most obvious question in one's mind when considering a departure from a presently successful method to one of unfamiliar characteristics is "What are the advantages in making such a move?" LPG, which from here on in during the course of this discussion will be considered "commercial propane," since this is the most desirable liquefied petroleum gas for motor fuel application in this section, has many real advantages and a few disadvantages which fortunately are not of overshadowing importance.

LPG has been called a dream motor fuel principally because it has features which eliminate some of the major problems that have been plaguing gasoline engine designers since their inception. Paramount among

. . . . engines using liquid petroleum gas have a number of advantages which include lower fuel costs, engine oil life is at least ten times longer, lower oil consumption and contamination, greater safety, lower maintenance costs and probably increased engine life. . . .

these features is the perfect vaporization of propane to a dry vapor. This single feature may readily be considered the greatest influencing factor on improved efficiency of propane fueled engines. In order to fully understand the importance of this feature, that is the utilization of a completely dry gas in contrast to a liquid fuel which must be vaporized by carburetion and manifold design on gasoline engines, let us review the following:

In gasoline engine design, one of the most difficult considerations has always been the uniform distribution of fuel to each cylinder. This can be appreciated when we realize that we are introducing a liquid fuel, through jets, into the air stream passing through the gasoline carburetor, and then providing external heat to the intake manifold together with baffles to promote complete vaporization and mixing of the fuel and air before it is delivered to the individual cylinders. Actually the uniform distribution of fuel-air mixtures to each cylinder on the gasoline engine has never been wholly accomplished.

Also, since the proper regulation of exhaust gas heat to the intake manifold is necessary to insure an approach to what could be termed a reasonable theoretical fuel

distribution, and we note that this heat regulation is supposed to be accomplished by an erratic and unreliable type of thermostatic heat riser valve which is usually inoperative in at least 20 per cent of all cases, we can more readily understand that there is a very basic reason for the relatively poor gasoline engine efficiency and economy.

In addition, gasoline carburetors are rather complex instruments made up of floats, valves, precision orifices, accelerator pumps and other items intended to effect greater efficiency in fuel utilization. When we realize that the gasoline carburetor is called upon to effect and maintain a reasonably uniform fuel-air ratio over varying conditions of load and acceleration by proportioning 12,000 air volumes to 1 liquid volume of gasoline, the enormity of this task is appreciated. Therefore slight changes in liquid fuel metering will completely upset the fuel-air ratio and this is magnified many times upon choking an engine and during gas acceleration when extremely rich, wet mixtures are induced into the cylinders. With consideration toward the problem of supplying fuel to six or eight cylinders from a central point through the branching manifolds, we can readily appreciate that the longer travel path of partially vaporized gasoline to end cylinders through a manifold heated by exhaust gases will certainly change the value of the fuel-air mixture entering the respective cylinders. This means that the BMEP will differ cylinder by cylinder, making for uneven engine operation and differential loadings on engine bearings and crankshaft.

One of the most detrimental effects of an incompletely vaporized fuel such as gasoline entering an engine cylinder, as is the case upon choking or fast acceleration in most engines, is the washing of the lubricant from the cylinder walls by this wet mixture. Obviously with the washing of the lubricant from the cylinder walls, wear is increased tremendously during these periods. The excess fuel, not burning completely, leaves a residue of carbon in the cylinder, and on the next cycle of choking or fast acceleration, the liquid fuel will wash these carbon particles down the cylinder walls with consequent additional wear on cylinders and rings. In addition the continuing dilution of the crankcase oil with gasoline lowers its viscosity, reduces lubricity and introduces acid forming compounds.

In contrast to these problems as noted with gasoline, propane enters the LPG carburetor, which is a simple air-fuel proportioning valve, as a dry gas. The proportioning problem is not nearly as difficult, since approximately 25 volumes of air are mixed with 1 volume of propane gas. There are no complex metering devices, orifices, etc., to wear or fail, and since we already have a dry fuel-air mixture, there is no need for providing heat risers, thermostatic valves and fancy manifolding to accomplish vaporization, as in the case of gasoline. Actually, on a propane engine, it is desirable to provide as cold a manifold as is possible and one without any impediments such as baffles or differential sizing. We can, therefore, through very simple manifolding, provide an air-fuel mixture of higher density and almost perfect uniformity to each engine cylinder. This, we believe, explains in part why many propane engines operate with a lower specific fuel rate than would be indicated by the Btu content of the fuel.

In this connection, we should also take up the subject of thermal efficiencies, for an internal combustion engine depends upon the conversion of heat energy to kinetic energy to furnish the ultimate power of the unit. Therefore, if we can digress a moment and talk about basic engine principles, we should point out the importance of maintaining the operating temperature of an engine to the highest practical limit (160 to 180 F) so as not to detract from the thermal efficiencies otherwise attained. A common fallacy prevalent in the minds of many motorists is associated with engine cooling system temperatures. We have all heard people boast that the temperature gage of their automobile never rises above some low reading, say 130 F. the truth is that such low operating temperatures are causing that particular motorist more trouble than good. Low engine operating temperatures obviously serve to reduce the net thermal efficiency of an engine, sometimes impede proper lubrication, and are paid for through excessive fuel and maintenance costs. It is, therefore, necessary to make sure that the engine cooling system is in good shape and that a high temperature thermostat is installed and functioning properly. It is a definite misconception that high temperature thermostats should be used only in winter time operation; high engine temperatures should be maintained regardless of season. The more heat made available in each cylinder, the more power will be delivered by the engine. Furthermore, in order to obtain high thermal efficiencies, we must supply as much fuel-air mixture to the cylinders as is possible. In the case of a fuel-induction type system as is used on the propane engine, the factor affecting the amount of fuel to a cylinder is obviously the density of such a mixture. This is the reason for cold manifolding with its greater volumetric efficiency in delivering a more dense fuel-air mixture to the cylinders. Thermal efficiencies of gasoline engines have been improved in the more modern engines by reducing intake manifold temperatures coincident with the availability of more volatile gasolines. Therefore we will note that propane fuel takes us in one jump from the necessarily heated intake manifold of the gasoline engine, with reduced thermal efficiencies, to the cold manifold with its inherent great improvement in thermal efficiencies.

Another very important advantage of propane fuel is its high octane number (115 to 125), as contrasted with premium gasolines at 90 octane. This high octane rating permits much higher compression ratios, which in turn increases the efficiency of the conversion of heat to power within an engine. The use of commercial propane as a motor fuel will permit compression ratios of at least 10 to 1. However, in the conversion of a gasoline engine to propane fuel, we cannot take complete advantage of the potential increase to this high ratio due to the inability of the gasoline engine construction to physically withstand the pressure developed at this high compression ratio. However, due to the lower Btu content of propane, we determine that the compression may be increased by at least one ratio without any adverse effect on the engine, and in many cases the compression may be safely increased beyond this point, depending upon the type of engine.

Another advantage of LPG fuel, ofttimes little appreciated, is its inherent chemical purity. Particularly

Figure 1 — Trucks may be refueled through the use of interchangeable fuel containers.

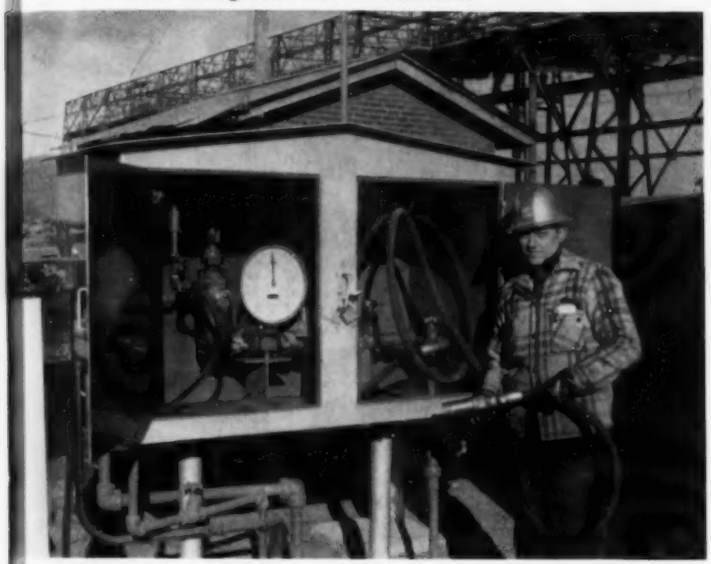


Figure 2 — Tanks are filled to about 80 per cent of the liquid volume.

is this true of commercial propane, which, when purchased on specification, provides a very uniform fuel product regardless of source. In contrast, gasolines may vary widely in their chemical composition, since they are almost generally composed of six or seven complex hydrocarbons, the composition of which varies according to the distillation points adhered to by the various refiners. A problem in engine design has always been to sufficiently compromise the nonuniform fuel situation with gasoline, so that reasonable engine performance could be obtained with any of the available gasoline fuels. Therefore, with gasoline fueled engines, we have both a nonuniform fuel and a nonuniformity in engines. If nothing else, the uniformity provided by propane will at least eradicate one variable in the situation and pose a challenge to the engine designer to build the ultimate in a power unit without compromises due to unknown fuel variations.

In addition, no additives such as antiknock compounds are necessary with propane and contaminates are almost nonexistent in high specification fuel. Inherent with high chemical purity of propane is its clean burning with very little carbon deposition in the engine.

To sum up the advantages heretofore discussed we will list the influencing characteristics of LPG and their attendant effects.

I. Complete Vaporization.
   1. No oil dilution.
   2. No cylinder washing.
   3. More easily proportioned as a fuel-air mixture.
   4. Almost complete combustion.
   5. Low carbon deposition.
   6. Greater volumetric efficiency.
   7. Higher thermal efficiency.

II. High Octane Number.
   1. Permits higher compression ratios with resultant increased thermal efficiency and smoother operation.
   2. No antiknock compounds required as additives, resulting in cleaner engines.

III. The Uniformity or Chemical Purity.
   1. Clean burning.
   2. Lower CO in exhaust gases.
   3. Exhaust gases free of physiological irritants.
   4. Improved engine efficiency due to consistent fuel value.

The disadvantages referred to earlier in this discussion are the higher vapor pressure, requiring pressure vessel storage and controlled handling, and the low specific gravity of the hydrocarbon, which results in lower Btu content per unit volume. The fact that commercial propane will average approximately 92,000 Btu's per gallon, in contrast to gasoline at 116,000 Btu's per gallon, would indicate that fuel consumption on propane equipment would be increased in the order of some 27 per cent. However, due to increased compression ratios, cold manifolding and the more complete combustion of the fuel itself, this apparent disadvantage

Figure 3 — An automatic shutoff facilitates the filling of cylinders.

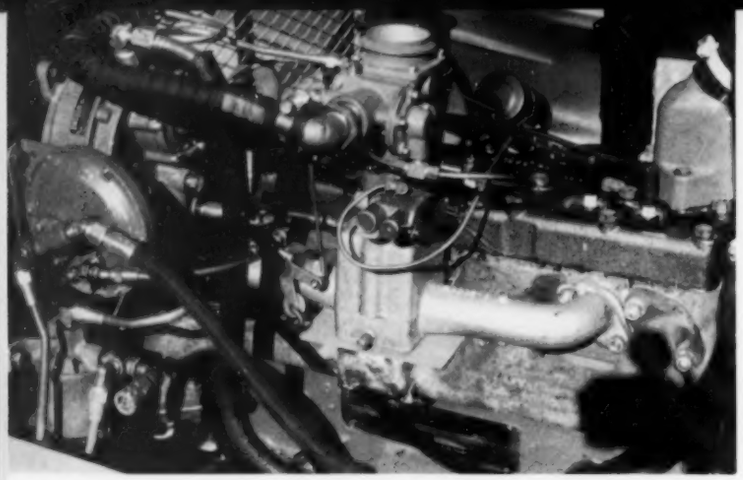


Figure 4 — Liquefied petroleum fuel requires cold intake manifolding.

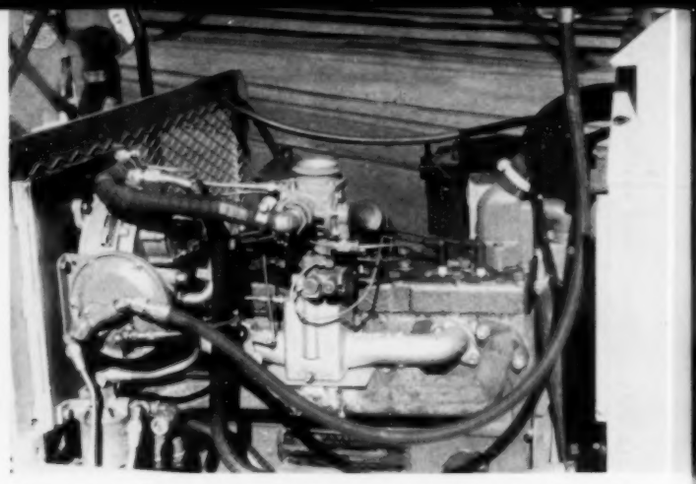


Figure 5 — A special fuel filter and vaporizer regulator are used.

is, in many cases, almost entirely overcome due to the great increase in thermal efficiency.

At this point it will be evident that special means must be taken in the handling and storage of the propane fuel, since we are dealing with a liquid having a boiling point of approximately −44 F. Standard propane containers applicable to industrial lift trucks, motor trucks and associated equipment, are of two types. The ICC demountable-type cylinder, manufactured in accordance with ICC specification 4-BA-240, is generally made in 20, 25, 33½ and 43½-lb propane capacities. These cylinders provide a means of interchanging fuel containers rather than having to run an industrial lift truck to a central fueling station, which in many operations is not practical. (See Figure 1.) For permanent fuel tank mounting an ASME specification U-69 tank is used. Both types of containers are equipped with fittings approved by the Underwriter's Laboratories and are designed for 250 psi working pressure.

The standard complement of fittings on an ASME tank includes a relief valve set for approximately 250-psi release, a liquid outage valve, a vapor outage valve, a liquid gaging device, a liquid filling valve, a vapor return valve and an 80 per cent liquid level bleeder.

The ICC cylinders on the other hand have only the 250-psi relief valve, a magnetic float gage, and a liquid or vapor outage valve. In the use of these ICC cylinders on lift trucks and other industrial equipment, where it is most desirable to fuel with interchangeable cylinders, an approved type of quick-disconnect, self-sealing coupling is used to make the connection between cylinder and the LPG fuel system on the vehicle. This coupling permits the rapid changing of cylinders without fuel leakage or loss due to the very effective sealing-off of the liquid fuel line when disengaging from the cylinder.

The ASME permanently mounted fuel tanks on motor trucks and on automobiles are, of course, fueled at a central fueling station where a special safety nozzle is employed to make the proper connection to the filler valve on the tank (Figure 2). All tanks are filled to approximately 80 per cent liquid volume, which is gaged by the 80 per cent level device previously mentioned. The adherence to this 80 per cent filling of cylinders and tanks is necessary due to possible increases in temperature after the liquid has been placed in the tanks. It is obvious that we must provide for ultimate expansion so that upon temperature rises, the liquid contained in the fuel tanks may expand without popping the relief valve. ICC cylinders are filled to the proper volume, determined by weight, usually on scales equipped with automatic shutoffs to facilitate such cylinder filling (Figure 3).

The subject of field conversion of gasoline engines to LPG fuel is a delicate one in the writer's opinion and is embarked upon with considerable trepidation due to the very grave possibility that many misconceptions may ensue. Basically the writer does not agree with much of the current sales promotion which would lead one to believe that marvelous results can be obtained in every case simply by making straight fuel conversions, that is, merely a substitution of gasoline carburetion equipment with the necessary components to supply the LPG fuel to the engine. It may be true, as indicated by the comments of others writing on this subject, that much of the potential advantage of LPG is gained from such a basic conversion. However, with recognition of the lower Btu content of propane, we believe that the only intelligent approach to automotive or industrial engine conversions should be one embodying engine changes which will permit the utmost utilization of this type of fuel. As indicated earlier, the high octane rating of propane will permit considerably increased compression ratios; attendant with these increased compression ratios will be higher internal cylinder temperatures, which may have to be reckoned with due to their effect on valves and valve seats. Cold manifolding should be a "must" in any conversion, since this may very well be the greatest influencing factor on net improvement.

Another problem not often recognized by people making field conversions is the change in ignition requirements which, of course, are influenced by the higher compression ratio and the combustion characteristics of the fuel. In many cases the distributor of a gasoline engine will not permit maximum utilization of the spark-advance curve and still provide sufficient retardation for starting.

Therefore, in the writer's opinion, the following changes to the gasoline engine should be effected on each propane conversion:

1. Provide cold intake manifolding (Figure 4).
2. Increase compression ratio at least one full number, or to the maximum degree recommended by the engine manufacturer.
3. Valve and valve seat changes to be in accordance

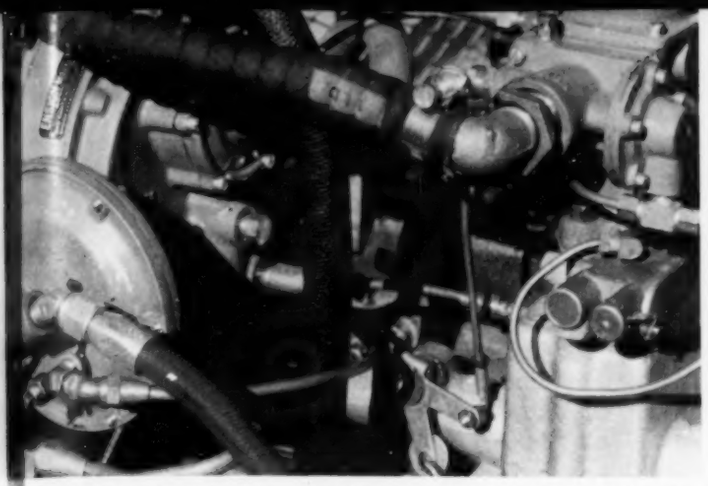


Figure 6 — A thin-walled neoprene hose is used for the vapor line from the converter to the carburetor.

with recommendation of engine manufacturer for this service.

4. Investigate availability of a special distributor (this is not a critical item but permits closer attainment of optimum operating condition).

5. Change spark plugs to one degree colder plug than normally used and check plugs during initial period of operation to determine whether still colder plugs would be desirable.

6. Insure that cooling system is in good condition and that high temperature thermostat is installed.

It is, of course, wise to start out with an engine in good physical condition; i.e., rings, bearings, etc., since an LPG conversion cannot be considered a cure for poor mechanical condition.

The LPG fuel system to be applied may be any one of a number available from reputable manufacturers and it is good practice to purchase a special propane carburetor rather than make what is termed a spud-in connection to the gasoline carburetor. While spud-in connections will provide the means to run an engine on propane, such installations are usually quite a compromise with the potential efficiency to be attained through use of carburetion designed expressly for LPG fuel.

As previously discussed, liquefied petroleum gas is contained in a special pressure vessel, mounted on the vehicle either as a permanent container or as an interchangeable fuel cylinder. Inherent high vapor pressure of the LPG fuel of course obviates the need for a fuel pump to move the fuel to the engine. Therefore, the conventional gasoline fuel pump is removed from the engine and the port covered with a plate. The liquid fuel from the storage tank or container is piped through approved high-pressure hose or copper or steel tubing to the engine compartment of the vehicle where it is successively piped through a vacuum or electric solenoid lock-off valve through a special fuel filter, and thence to the vaporizer regulator (Figure 5).

Up to this point we have a liquid which may have a vapor pressure varying between 20 psi at 0 F to 160 psi at 100 F, depending upon prevailing ambient temperature. The vaporizer regulator will perform the dual function of vaporizing the liquid fuel to a dry gas and reducing the pressure in two stages of regulation to a point somewhat below atmospheric pressure at its outlet.

In order to effect the rapid vaporization of the liquid fuel as required by engines operating at high speed and/or under load, heat must be applied to the vaporizer. To accomplish this we circulate hot water from the engine cooling system through the vaporizer portion of this converter. Here it may again be noted that close control of engine temperature will also insure that the vaporized fuel will have a reasonable uniformity of temperature. The temperature of both the fuel vapor and air entering the carburetor would under ideal conditions be the same, since the proportioning of gas volumes can be most accurately accomplished when both components are at the same temperature.

At this point we should discuss the method of starting cold engines using propane as a fuel. Obviously no heat would be applied to the vaporizer from the cooling system. Therefore, in the case of vehicles fitted with permanently mounted ASME fuel containers on which, as previously noted, there is a vapor withdrawal connection, the practice would be to shut off the liquid fuel supply at the tank and open the vapor outlet valve to permit utilization of the vapor inherently filling the volume of the fuel tank over the liquid. Withdrawal of this vapor from the fuel tank will, of course, reduce the pressure on the liquid, permitting further vaporization of the liquid. Sufficient vapor will be furnished to supply the amount of fuel necessary for engine idling during warm-up. However, the rate of vaporization in the tank under very low temperature conditions will not be sufficient to supply an engine's fuel requirements at high rpm or operating load conditions. Therefore, the vapor should be used only to start the engine and during warm-up period at moderate rpm until the engine has come up to proper operating temperature. The vapor valve is then closed and the liquid valve opened so that the required fuel flow will be provided.

On industrial units such as lift trucks, etc., using interchangeable ICC cylinders containing only the liquid outage valve, the liquid fuel must necessarily be supplied to the converter. On these units, therefore, the flow of fuel to the engine is dependent upon the natural vaporization of the liquid propane through the successive stages of pressure reduction in the converter. This also requires that, upon starting, the engines must be idled at low rpm until the engine operating temperature has been attained. Surprisingly enough, most industrial equipment of this type, due to low fuel requirements, will start very readily in cold weather, usually with less problems than gasoline equipment with their inherent choking troubles, if ignition and starting systems are in good condition. The overspeeding of an engine during this warm-up period in extremely cold weather might, however, cause a freeze-up in the vaporizer due to the extreme cooling resulting from rapid vaporization of the liquid fuel.

As previously noted, the dry vapor available at the outlet side of the vaporizer regulator is at, or slightly under, atmospheric pressure. The connection between this outlet and the propane carburetor should be as short as possible, and of a size that will maintain the potential flow as governed by the vaporizer regulator outlet. This vapor line from the converter to the carburetor is usually made with extremely flexible, thin-walled neoprene hose containing steel braid or spiral wire (Figure 6). The steel wire or braid of the hose should be exposed at either end and grounded to the

metal body of the carburetor and converter, respectively. This is done to insure the rapid dissipation of static electricity which may be generated by the high velocity of the dry propane vapor under extremely heavy fuel requirements.

The propane carburetor is a rather simple fuel-air mixing valve, the vapor being introduced into the air stream at the carburetor venturi and is proportioned by very simple valves, which, when once set up to proper fuel-air ratio, will usually maintain their adjustment for interminable periods. On engines in the higher horsepower range, some carburetion equipment will include separate idle fuel supply lines and fuel balance lines to the converter. The separate idle fuel line permits more accurate proportioning of fuel under idle conditions, and the balance line is another refinement which compensates for varying aircleaner resistance, thereby providing a greater uniformity of fuel air mixture under various operating conditions.

It is not the purpose of this paper to discuss the specific details of installation practices and materials since this information is available from many authoritative sources and is basically governed by the rules set forth in Pamphlet No. 58 published by the National Board of Fire Underwriters and recommended by the National Fire Protection Association. We should point out at this time that all propane conversion components must be Underwriters' Laboratories approved and that the individual conversions must be approved by the fire insurance underwriting company interested in the location of use. All equipment furnished by manufacturers powered by propane engines as a complete installation carry such approval. Furthermore, the various service organizations installing LPG conversions usually have a well defined procedure of installation and will be responsible for gaining complete insurance approval on their conversions.

At the Bethlehem plant of the Bethlehem Steel Co. we are currently operating twenty-one industrial lift trucks and eight highway trucks on propane fuel. The initial conversion was made in September of 1954, and with the exception of four highway trucks, all conversions were performed in our own shop. The four motor trucks were purchased as complete factory installations, with engines sufficiently modified to closely approach the optimum design for propane fuel.

Even though we have had considerable experience with this equipment, we do not feel that sufficient time has elapsed to finally evaluate the advantages costwise. That is, we have not built up sufficient engine operating hours to fully determine the end result on overall engine life and maintenance. Indications are, however, very encouraging based on inspection of engines run on various cycles of work. Fuel savings on the order of $0.04 to $0.05 a gallon are, however, a certainty, but since our primary interest was in alleviating the rather costly maintenance experience inherent with our gasoline fueled industrial engines, we do not, therefore, have the final answer to the overall problem.

Based on experience to date we can state that considerable savings in addition to those on fuel are accruing from increased life of engine oil, oil filters and spark plugs. The complete teardown of one of our propane fueled engines having the equivalent service of 50,000 miles provided data which would indicate that additional engine life in the order of at least two to three times the original service could be expected.

A summation of the advantages we recognize in LPG as a motor fuel are:

1. Lower fuel cost.
2. Longer engine oil life (at least 10 times).
3. Lower oil filter cost (less oil contamination).
4. Increased spark plug life.
5. Greater safety
    1. No fuel spillage.
    2. Less explosive hazard.
    3. Lower CO in exhaust gas.
6. Lower current maintenance cost.
7. Indicated increased engine life.

DISCUSSION

PRESENTED BY

ROBERT TURNER, Electrical Engineer, United Engineers & Constructors, Inc., Philadelphia, Pa.

P. F. WALKER, Mechanical Engineer, Service Division, Bethlehem Steel Co., Bethlehem, Pa.

JACK BOOTH, Service Engineer, The Yale & Towne Manufacturing Co., Philadelphia, Pa.

STEVE CURTIS, Chemical Engineer, United States Steel Corp., Fairless Works, Fairless Hills, Pa.

Robert Turner: Is there any tax similar to the gasoline tax on liquid petroleum gas?

P. F. Walker: Liquid fuels tax applies if vehicles are licensed, industrial equipment does not incur tax.

Jack Booth: We have been using propane conversions on our engines for approximately four years and to date we have run approximately 10,000 hours on one engine, torn it down and found no carbon on either the cylinder walls, piston heads or the head itself.

We have made quite an exhaustive study with our automatic transmission lately using the propane setup for test purposes. By taking Orsat tests we have found that propane expels approximately 50 per cent less carbon monoxide than straight gasoline.

The cylinders and tanks have safety features built into them. There is an internal relief valve that will allow vapor to escape when tank pressures are too high. An excess flow valve instantly acts to shut off fuel in event of line breakage. These safety features include self-sealing couplings, oil pressure switch, pressure relief valve between fuel container and solenoid safety valve. Safety valve automatically locks off flow of fuel when ignition is off or engine stalls. This does away with most of the hazards of propane fuel as it normally lays low, and these safety features are necessary. It is a cheaper and better burning fuel, and with a cold manifold you get better vapor rolling qualities into your cylinders which gives better fuel distribution. We have found that the compression ratio can be increased approximately two points.

Steve Curtis: We have several units at Fairless Works and although we feel it is too soon to judge, the results appear to be encouraging.

Application of Eddy-Current Adjustable drives in the steel industry

....in an eddy-current coupling, speed or torque is regulated by a control which varies the current in a single field coil per section.... advantages are low initial cost, compact floor space, simple construction and low maintenance and operating costs....coupling can be built in sizes from 1 to 20,000 hp....

By

THOMAS SKARAKIS, Application Engineer, Dynamatic Div., Eaton Manufacturing Co., Kenosha, Wis.

▲ THE steel industry today is faced with greater demand for increased production, reduced costs, improved quality of product and more complex processing techniques than ever before in its history. Adjustable speed drives are playing an increasingly important role in the attainment of these objectives.

Although it is relatively a newcomer to the field of adjustable speed drives, the eddy-current coupling is rapidly gaining popularity in the steel industry where it has given a good account of itself. The eddy-current coupling is used in conjunction with either a constant-speed, squirrel cage motor or a synchronous motor to provide a wide range of stepless, adjustable speeds from an alternating current power source. Output speed or output torque is regulated by a control system that varies the current in a single field coil per section. Large couplings may be built with multiple sections.

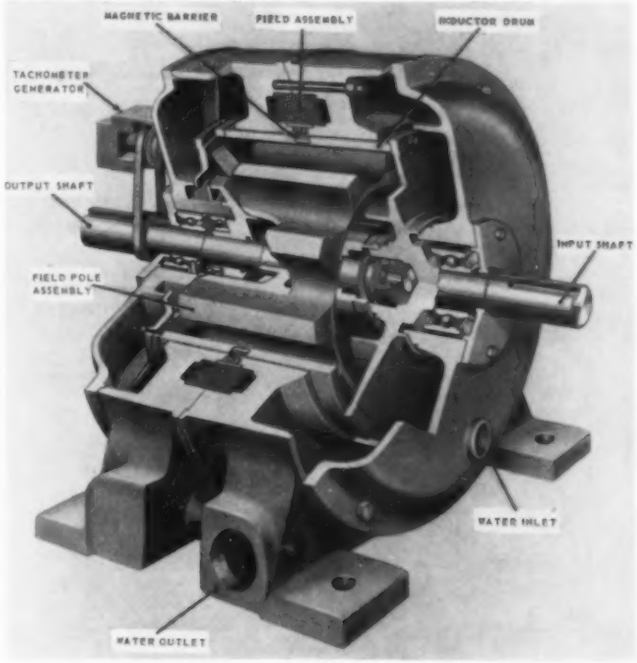
BASIC PRINCIPLES OF OPERATION

While the parasitic effect of eddy-currents in rotating electrical equipment is well known to electrical manufacturers, very little was known about the deliberate generation of eddy-currents prior to the design of the original eddy-current coupling. All effort in research and development had been directed to the elimination of eddy-currents in rotating equipment in order to increase efficiency. In the development of the eddy-current coupling, these parasitic currents were "put to work" successfully to transmit torque.

Figure 1 is a cutaway view of a stationary field eddy-current coupling incorporating the latest design improvements in eddy-current drives. The driving member of this coupling consists of the inductor drum on the input shaft which is coupled to the drive motor and rotates at a constant speed. The output member includes the field pole assembly and the output shaft and rotates at speeds determined by the setting of the control. The field assembly encircling the inductor drum provides the primary field necessary for the generation of the eddy-currents in the inductor drum. The inductor drum is divided into magnetically isolated sections by a nonmagnetic metal ring called a magnetic barrier.

Figure 2 is a diagram showing the distribution of magnetic lines of force in the inductor drum and field pole assembly. These lines of force flow from the north polar ring of the field assembly through the adjacent section of the drum into the poles of the field pole assembly and through the opposite section of the drum back to the south polar ring of the field assembly. As

Figure 1 — Cutaway view shows stationary-field eddy-current coupling.



shown in Figure 2 the distribution of the magnetic lines of force in the outer surface of the inductor drum is relatively uniform. The lines of force converge at the inner surface of the drum as they flow into the field poles. This causes localized areas of high flux densities in the drum's inner surface adjacent to the field poles and starved areas in the drum surface opposite the spaces between the poles of the field pole assembly. As the inductor drum revolves in relation to the field pole assembly, the flux density at any given point on

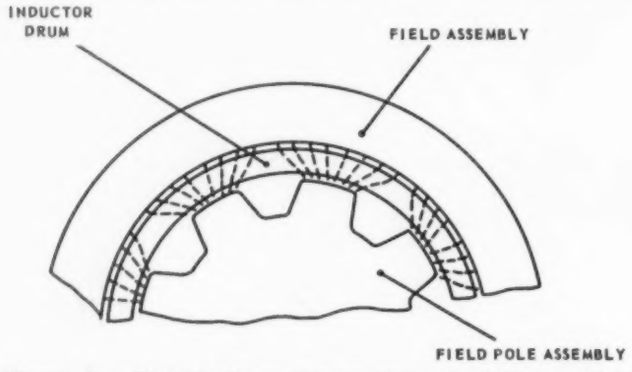


Figure 2 — Sketch shows flux pattern of stationary-field coupling.

the drum's inner surface varies as that point passes the alternate poles and the grooves between the poles of the field pole assembly. This variation in flux density generates eddy-currents on the inner surface of the drum adjacent to the field poles. The secondary magnetic field induced by these eddy-currents has a polarity opposite to that of the primary field established by the coil of the field assembly. Torque is transmitted from the inductor drum to the field pole assembly by a magnetic attraction between the two rotating members.

The magnitude of the secondary field varies with the rate of flux variation in the drum's inner surface. The rate of flux variation is a direct function of the amplitude and frequency of the variation. Amplitude varies with primary field strength while frequency varies with the slip or difference in speeds of the drum in field pole assembly. An increase in load tends to retard the rotation of the output shaft and increases the slip between the field pole assembly and the inductor drum, causing an increase in the frequency of flux variation that intensifies the secondary field in the drum. As the field coil current is increased, less slip is required to generate the attracting eddy-currents because of the resultant increase in the amplitide of flux variation, and the speed of the field pole assembly will approach the speed of the drum. Output speed control may be obtained with a control system that adjusts field coil amperage to deliver the required torque at the desired slip.

Figure 3 — Torque characteristics of stationary-field coupling.

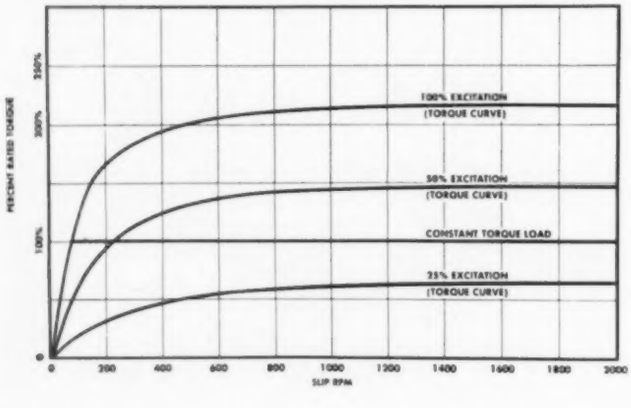


Figure 3 shows the torque characteristics of the coupling. The curves in this figure show an increase in torque with increasing slip between the driving and driven members for a given excitation of the field coil. In selecting the proper size of coupling for a given application, the normal practice is to select a unit that delivers the rated torque at a slip speed approximately three to five per cent of motor speed. This means that the rated torque is approximately 40 to 50 per cent of the peak torque available. If a coupling is sized to deliver its rated torque at a slip speed exceeding three to five per cent of motor speed, the peak torque available is reduced.

Eddy-current couplings are normally rated on a constant torque basis for most applications. As shown in Figure 3, at high slip values sufficient excess torque is available for starting, acceleration and for momentary peak loads. Continuous duty is possible anywhere, within the envelope of the 100 per cent excitation curve provided the thermal capacity of the unit is not exceeded.

Figure 3 illustrates torque curves plotted at three constant values of field coil excitation. However, an infinite number of field coil excitation values are attainable with the simple and versatile electronic control system, and consequently, an infinite number of speed-torque characteristics can be obtained. The exceptional flexibility of the coupling and its control make it adaptable to a wide range of adjustable speed requirements.

EFFICIENCY

Factors affecting coupling efficiency are slip loss, friction, coolant acceleration, excitation and magnetic drag. Of these the slip loss is by far the largest and its magnitude depends on operational factors. Other overall operating losses at rated speed and torque are approximately:

Windage and friction	0.25
Coolant acceleration loss	0.5
Excitation	1 or less
Magnetic drag	1 or less

Generally speaking at 75 per cent speed to rated speed, a coupling in combination with a squirrel cage driving motor has a greater efficiency than a d-c motor and generator set at equal capacity. At speeds below 75 per cent, the d-c system usually has some efficiency advantage, while above that point the motor coupling will normally show an advantage.

COOLING

All energy lost in slip between the driving and driven members of the coupling is converted to heat, which is concentrated in the inductor drum. This heat is proportional to the slip loss, and is greatest when transmitting high torque at low output speeds. To dissipate this heat, air and liquid cooling systems are used.

The coupling illustrated in Figure 1 is a heavy-duty, liquid-cooled model. A flow of coolant is introduced through a nozzle on the output end bell and flows into an annular chamber in the output end of the inductor

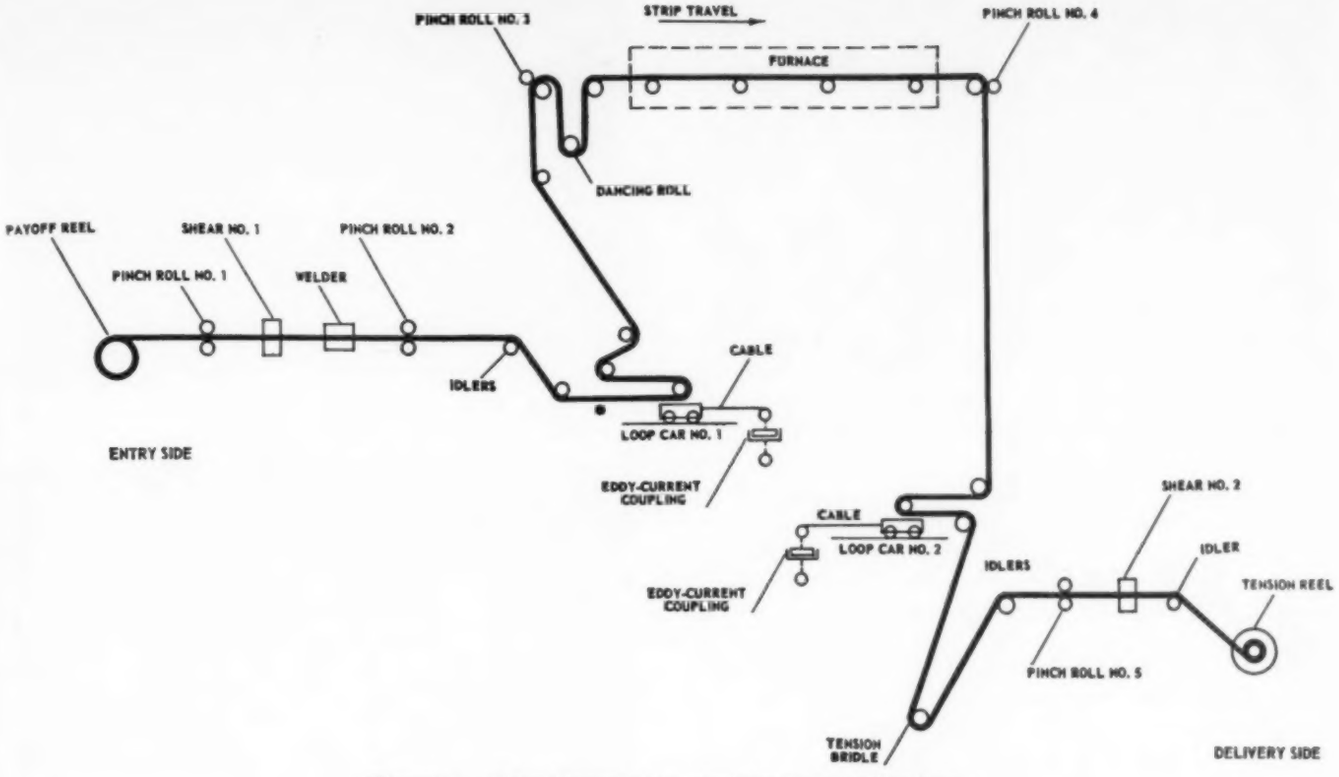


Figure 4 — Flow diagram for steel strip annealing line.

drum assembly. Centrifugal force carries the coolant into the air gap and across the inner surface of the drum to carry away the heat developed by the concentration of eddy-currents. The coolant leaves the drum through holes drilled radially about its input end and collects in the sump of the coupling.

Pressure and temperature protective devices and an automatic modulating valve supplied with the couplings insure minimum adequate cooling flow for all normal operating conditions.

Air-cooled couplings, differing slightly in design from the liquid-cooled model, are available in horsepower ratings up to 75 hp.

CONTROL

The direct current required for field coil excitation is very small in relation to the power transmitted. A unit rated 2000 hp at 1200 rpm requires only four kw excitation, which is easily provided by a small electronic or magnetic amplifier power source.

Because of the low power requirement and the sensitivity of the electronic control, very close speed regulation may be achieved with the eddy-current coupling. Standard control systems furnished with the units are capable of holding a constant speed within two per cent of maximum speed with a 75 per cent change in load. With a special control system, speed regulation may be held to 0.1 per cent of maximum speed for a 75 per cent load change. A tachometer generator, shown in Figure 1, is driven by the output shaft of the coupling to provide a speed sensing signal in the control system. The voltage produced by this generator is directly proportional to the speed at which it is driven and it is compared against a reference voltage determined by the speed setting potentiometer to maintain any preset speed.

All control systems operate from an alternating current source and may be supplied by existing electric power facilities.

In addition to the basic speed control function of the coupling and control, any other control functions are available. These include preset multiple speeds, threading, inching, controlled acceleration and deceleration, torque limit, multiple drive speed matching, multiple drive cascade and constant tension for winder and holdback operations.

APPLICATION OF COUPLING TO MILL OPERATION

Many mills have used the eddy-current coupling on numerous applications such as single-stand, cold-finishing mill, cleaning lines, pickling lines, trimming lines, tin plate lines, annealing lines, slitter lines, and winding and holdback operations. The use of the eddy-current coupling and a-c squirrel cage motor combination has proved very successful used with the multiple d-c drive system of a steel strip annealing line. Figure 4 is a material flow diagram of this annealing line.

It is necessary to maintain a continuous flow of material through the annealing furnace at all times, even during the time when the entry or delivery side of the line is stopped to change payoff or tension reels. During shutdown of the entry side of the annealing line, material is fed to the furnace from the storage loop created by loop car No. 1. A second storage loop, created by loop car No. 2, allows the annealed material to accumulate in storage during the changing of the tension reel. Each loop car is operated by a winch powered by an a-c motor and an eddy-current coupling.

As a new payoff reel is installed, holdback tension on the strip is exerted by pinch roll No. 2. This tension exceeds the tension exerted on the strip by loop car No. 1, and material is fed to the furnace from the storage loop. After the new payoff reel is installed and the strips are welded together, holdback tension is removed

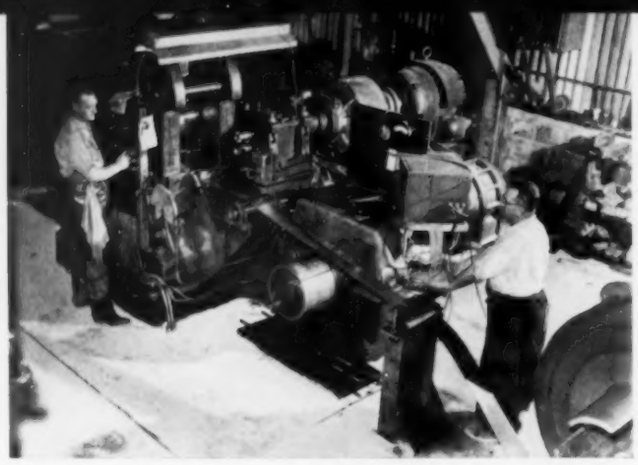


Figure 5 — An eddy-current coupling is installed in this single stand reversing cold finishing mill.

from pinch roll No. 2 and the loop car is permitted to draw up another storage loop. To prevent overspeeding of the loop car when the holdback tension is removed, a speed control function is performed by the eddy-current coupling and its control. When the loop car reaches its maximum position, the pull of the entry pinch roll equals the pull exerted by the coupling, and the car remains in this position.

In the delivery side of the annealing line, another loop car is used to provide a storage loop when the delivery section is stopped. Normally the tension exerted on the strip by the tension reel exceeds the tension exerted by loop car No. 2, and no material is held in the storage loop on the delivery side of the furnace. However, while the tension reel is changed, pinch roll No. 5 clamps the strip and produces a static tension that permits car No. 2 to draw up a storage loop. The speed of the loop car is controlled by the speed control function of the coupling to maintain tension in the strip as it moves away from the delivery end. As soon as the delivery end is started again, tension exerted on the strip by the tension reel draws the loop car toward the delivery end of the annealing line, as the tension reel takes up the material held in the storage loop during the changing operation. Loop car No. 2 remains in this position until the next tension reel is changed.

Loop car drives using eddy-current couplings have been installed in mills at Butler, Pa.; Middleton, Ohio; Ashland, Ky.; Birmingham, Ala.; and Chicago, Ill.

Figure 5 shows a typical installation of the eddy-current coupling and a-c squirrel-cage motor applied to a single-stand, reversing cold roll finishing mill. A 300 hp, a-c motor and eddy-current coupling are used for the main drive and two 50-hp, a-c motors and eddy-current couplings are used as the takeup drives.

Figure 6 shows the application of the eddy-current coupling and a-c synchronous motor on a steel slitting line. The 200-hp synchronous motor and coupling are used to power the winder and slitter. A scrap winder on this unit is powered by a 5-hp air-cooled, eddy-current unit. A 25-hp unit on the payoff reel controls holdback tension by applying torque to the reel in the opposite direction to that of the torque applied by the 200-hp winder and slitter drive. Several leading manufacturers of steel slitting equipment supply this type of drive with their slitters.

A 60-hp, 1165-rpm squirrel-cage induction motor and eddy-current coupling shown in Figure 7 are used on a ten-stand metal forming mill.

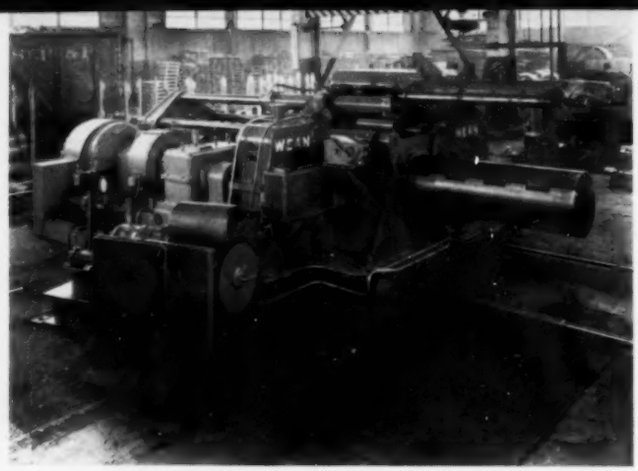


Figure 6 — Steel slitting lines offer a good application for eddy-current couplings.

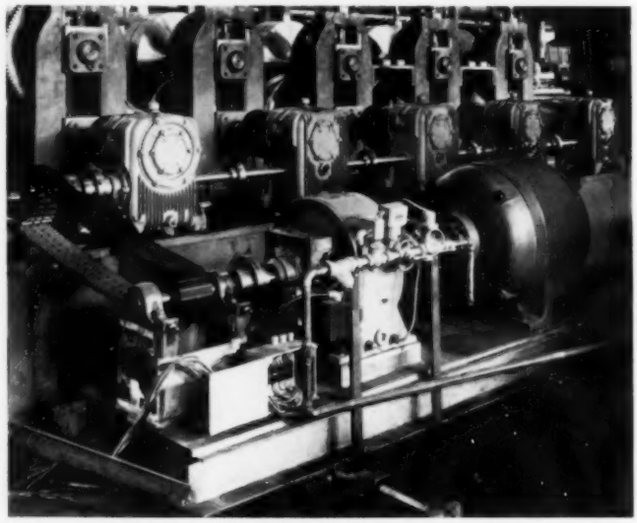


Figure 7 — A 10-stand metal forming mill is driven through eddy-current coupling.

SUMMARY

The stationary field eddy-current coupling with its many types of versatile controls offers a good solution for the adjustable speed drive applications in the modern steel industry.

The advantages realized in using this drive are many:

1. The overall installation and cost of the drive equipment is low.
2. The overall floor space required by the drive and its control is small.
3. The simplicity of construction of the coupling and its control offers maximum flexibility for adjustable speed operation.
4. Maintenance operating costs are low due to the long trouble-free operation that can be had from the coupling drive.
5. No collector rings or commutator assembly is required as means of bringing excitation to the unit from the control.
6. The liquid cooled units offer a totally enclosed drive for operating in dirty atmosphere.
7. The high efficiency of the coupling at top speed gives economical operation.
8. The simple construction of the coupling means repairs, when necessary, can be quickly made at relatively small cost.
9. The coupling is built in a wide range of sizes and capacities, ranging from 1 to 20,000 hp. Therefore, it can be adapted to most requirements.

By ROBERT A. SMITH

Assistant General Foreman, Hot Strip Rolling, Jones & Laughlin Steel Corp., Pittsburgh Works Div., Pittsburgh, Pa.

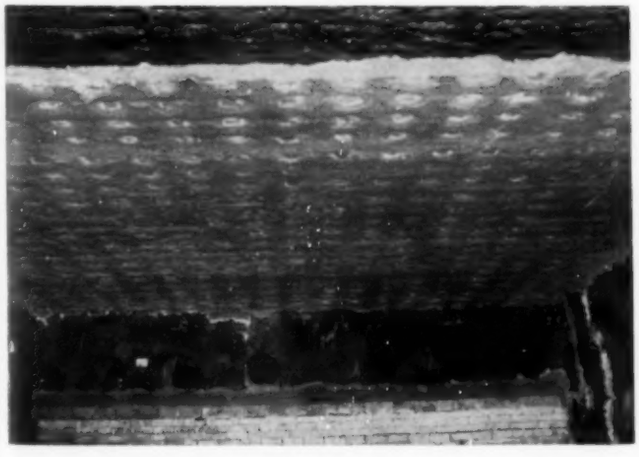
PLASTIC REFRACTORY In Slab Heating Furnaces

▲ THE use of plastic refractory is not new to the steel industry, as numerous applications have been made in boilers and other industrial furnaces during the past 20 years. However, its uses are relatively new in strip mill slab heating furnaces.

Perhaps it might be well to define *Plastic Refractory*. Plastic refractory is a combination of materials that have the capacity to resist high temperatures and are pliable and capable of being molded into a monolithic structure. The materials used are generally plastic bond clays and calcined, crushed flint clays, blended with other materials, and tempered with water. We believe that we have pioneered many plastic installations in slab heating furnaces. In the early 1940's, we used plastic refractories, but only as patch work or for emergency repairs. It was not until November, 1949, that we made our first large installation. At that time we installed a flat roof in the hot zone of one of our slab heating furnaces.

Figure 1 shows the section in our original installation. The size of this section was 18 ft wide, 19 ft long, and 9 in. thick. The roof was hung by means of 3-in., I-beams welded and bolted to the original box channel brick hangers. These beams were placed on 12-in. centers, and the anchor tile, also on 12-in. centers, were hung by means of a casting which slid over the flange of the beam. Our experiences with plastic roofs were not good in the beginning. In some instances we learned the hard and expensive way, but feel that with our failures, better methods of installation were brought out

Figure 1 — The first large installation was the flat roof in the hot zone of the slab heating furnace.



. . . . plastic refractory installations provide greater furnace availability, enable harder forcing of furnace, secure greater output and reduce premature refractory failure . . . .

which resulted in improved performance. Our greatest problems were in developing the proper density and the correct curing of the material.

It might be well at this time to mention the importance of the proper curing or baking in a plastic refractory. The drying out period cannot be hurried. We have had several unfortunate experiences where we attempted to rush the drying out time. If the temperature of the furnace is brought up too fast, the moisture in the material will set up thousands of tiny steam explosions and cause the material to shell off in a layer. A temperature increase of no more than 100 F per hour for the first 12 hr is advisable, and the total drying out period should consume 24 to 26 hr. Also found to be very important to the curing of a plastic installation is the perforation of the finished job. A $\frac{1}{8}$-in. rod should be used and the perforating should be done from both the inside and the outside of the furnace. The holes should be made about 3 to 4 in. apart. This allows the steam to escape without building up pressure and without doing any damage to the plastic material. We have since extended our original roof installation to include the slope to the lower knuckle.

During our early experiences, we found that a section of the roof about six ft deep across the width of the furnace in the top zone was spalling. This occurred at the initial combustion point approximately four ft from the face of the burner wall. To correct this condition, we made three changes.

First, by removing the original box channels and welding the 3-in., I-beams to the 12-in. cross beams, we were able to raise the roof approximately seven in.

Second, we changed the thickness of the plastic roof from 9 to 7 in., thereby gaining another 2 in. in height. This thinner roof also resulted in reducing the curing time.

Third, we installed a plastic top burner wall, and by changing the slope of the top of the burner ports, we

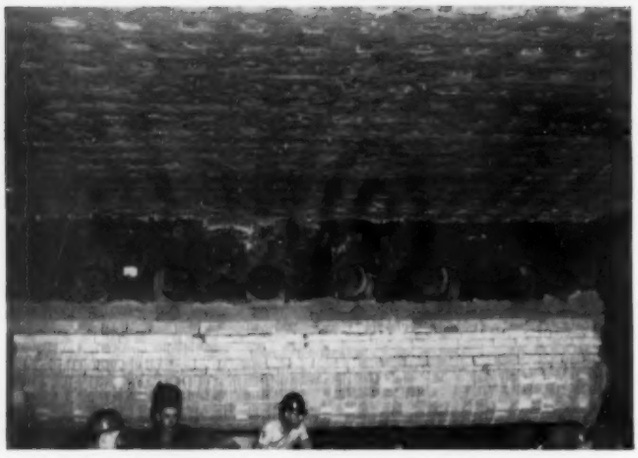


Figure 2 — New brick knuckle and nose and rammed plastic roof were put in this furnace.

changed the angle of the gas flow. To alter the angle of the fuel pipe would have been costly.

Steel forms for the burner ports were fabricated in our structural shop. They were set into place as the plastic material was rammed on top of the lintel. The tilted burner ports directed the flow of gases so that the initial combustion was away from the roof and the flame did not impinge on the steel.

We have been very well satisfied with the performance of plastic refractory in the top burner walls. At the present time we have one furnace with the burner wall going into its fourth year of operation without a failure or without having any major repairs. Now the other two furnaces have similar plastic burner walls which seem to be performing just as well.

Figure 2 shows the condition of the old burner wall mentioned with the new brick knuckle or nose and rammed plastic roof. At this time, the method of supporting plastic roofs and anchoring plastic walls with corrugated refractory anchor tiles should be mentioned. The tiles are manufactured or first quality refractory clays, fired at high temperatures to eliminate shrinkage, increase strength and reduce thermal checking. The anchor tile is constructed with corrugations on four sides. The number of corrugations vary from two to four depending upon the thickness of the plastic material used.

Hanger tile are susceptible to spalling. Periodic gunning of a refractory material will make a quick repair, prevent cutting out of the plastic around the anchor tile and increase the life of the roof. Gunning the roof or walls of a furnace is the application of a refractory material with an air placement gun. Air pressure forces the dry material through the gun into the hose, and the proper amount of water is mixed at the nozzle by the operator.

The proper wetting of the gunning material can be learned only by experience. We have found that a coating (approximately ¼ to ½ in. thick) applied a little at a time, will bond and stay on much better than will a heavy coating. Also of interest is the fact that in case of an emergency where outage will not permit cooling down of the furnace, the material can be gunned from the outside. However, we try to plan our gunning maintenance when the furnace is down, as a much better job can be done from the inside of the furnace.

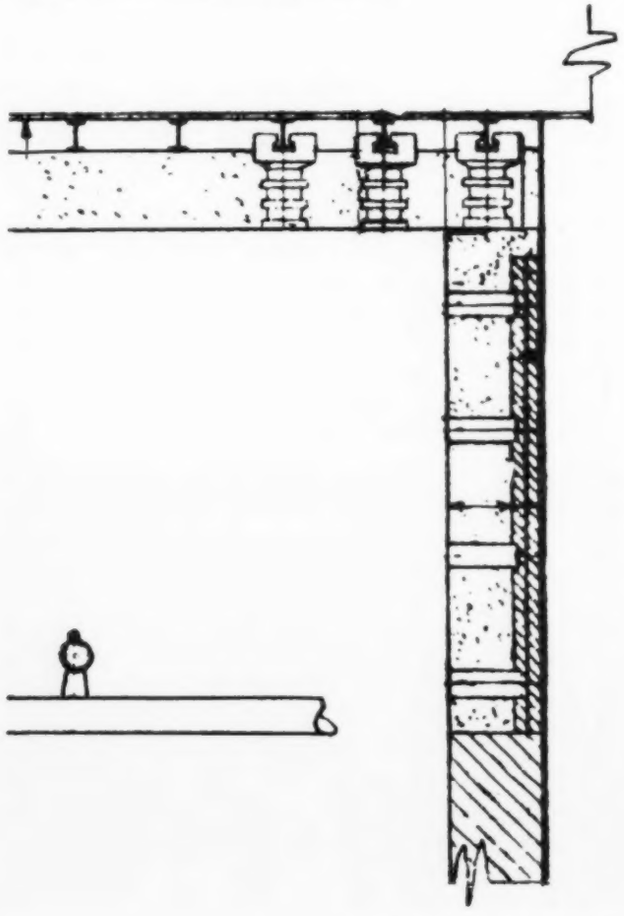
Figure 3 is an actual photograph taken immediately after completing a gunning job. The nozzle operator and his helper are standing on the top of the slabs in the furnace, dressed in protective clothing made of aluminized asbestos material. Note the necessary safety equipment, goggles, respirator and wooden sloppers.

Figure 4 is a cross section of a plastic roof showing the 3-in., I-beams and the corrugated anchor tile with the plastic material rammed around the tile.

It was in July of 1951, after many experimental applications and emergency repairs, that we made our first major rammed plastic installation in a side wall. This

Figure 3 — Protective clothing make men look like they are ready to travel into outer space.

Figure 4 — Cross section of plastic roof shows 3-in. I-beams in corrugated anchor tile.



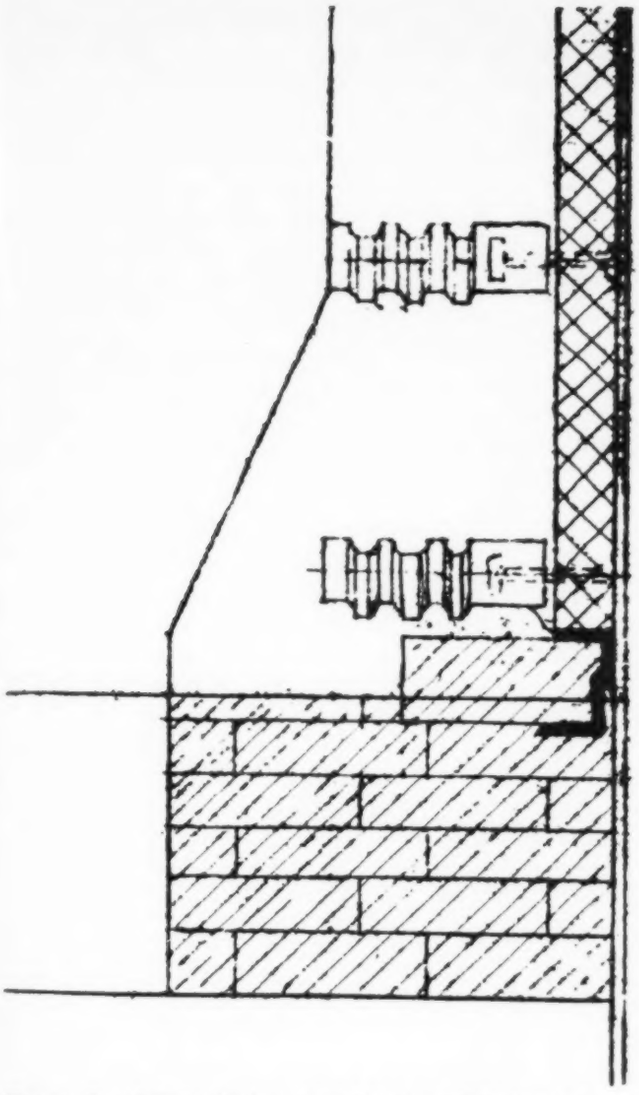


Figure 5 — About 18 in. of firebrick underpinning are used.

installation was a test patch, 6 ft high, 10 ft long. The plastic material was 7½ in. thick, backed with 2½ in. of block insulation. The reason for the test installation was to determine if a 10-in. thick wall could satisfactorily replace the existing 18-in. thick fire brick wall. The patch was placed in the center of the hot zone, normally the heaviest fired part of the furnace. Thermocouples were installed at the inner and outer surfaces of the 10-in. test panel and the adjoining 18-in. fire brick wall. Surprisingly, with approximately the same temperatures on the inner faces, the temperatures of the outside steel plates were comparable. The ambient temperatures were within 15 F of one another. The average recorded temperatures were as follows:

The inner face was 2500 F, the junction temperature 1400 F, the plate 300 F, and the ambient temperature 130 F. After many months and numerous studies, we felt confident that the rammed plastic had the insulating value, high heat storage capacity, high mechanical strength and resistance to combustion velocities to do the job.

In November, 1952, we installed 10-in. plastic walls in both sides of the hot zone of one of our furnaces. Similar installations were made in our other two furnaces and proved very satisfactory. In February of 1955, we widened our No. 2 furnace by installing 10-in. walls from one end to the other. In July we made the same type of installation in our No. 1 furnace, and No. 3 furnace was completed in November.

At this time it may be well to explain the construction and tying in the plastic wall and supporting the roof. The anchor tiles are set 18 in. on centers in the side walls and on 12-in. centers in the roof. In the preheat zone side walls, split 3-in. I-beams were used to anchor the tile. The beams were split in half forming T bars which were welded vertically to the side plates of the furnace. The hanger castings are slid over the flange of the T bar and the tiles are attached as they are set in the plastic. In the heating and soaking zones, rather than use T bars, it is recommended, because of the higher temperatures, that high heat resisting alloy bolts be used, either welded to or bolted through the outside plates. By extending the bolts through the plates, the heat will dissipate faster and withstand higher temperatures with safety. The head of the bolt and the attached washer should be free enough in the slot in the tile to permit ample movement, so that as expansion or contraction takes place it does not bind or cause strain on the tile.

An 18-in. fire brick wall is first laid up from the floor of the furnace to an elevation approximately 12 in. below the bottom of the main skid line. Then the plastic is started and tapered back to 10 in. thick. The 10-in. section consists of one 2-in. block and one 1-in. block of insulation laid up with staggered joints and faced with 7 in. of plastic refractory.

In Figure 5, note the 18-in. fire brick underpinning, the corrugated anchor tile, insulation blocks and the wall taper of the rammed plastic construction.

The plastic is installed with pneumatic rammers, assuring more uniform density throughout. This uniformity is of the utmost importance, as jobs installed manually using wooden mallets or steel hammers will have some areas of the construction more dense than others. When expansion and contraction occurs due to

Figure 6 — Wall is trimmed even with the face of the anchor tile.

Figure 7 — Plastic door arches are rammed around wooden forms.

heating and cooling, numerous checks and cracks will develop.

Figure 6 is a view of the side wall at the charging end of the furnace. Note that the wall has been trimmed or shaved even with the face of the anchor tile. This should be done as the ramming proceeds.

Figure 7 of the side wall in the soaking zone shows the observation ports. The plastic door arches are rammed around wooden forms of right size and set at the proper elevation. The forms are removed upon completion of the job. It is also important that when "closing in" at the junction of the roof and wall, a tight seal be made.

As stated earlier and well worth mentioning again, the proper venting of a plastic installation is very important. One must not forget that upon completion of the work, the proper curing and drying out of the plastic will be a big factor in the success and performance of the job. When lighting up the furnace, it is suggested that all concerned be made familiar with the proper and correct procedures. It is also advisable that a written schedule, showing the recommended hourly temperature increases, be posted at the furnace for the use of the heaters in charge of this work.

We feel that through the use of plastic refractory, we have been able to improve the efficiencies of our furnaces. The heat storage capacity of plastic refractory along with its ability to radiate heat has reduced fuel consumption and resulted in lower fuel costs. We also know that the average refractory life of our furnaces has been lengthened. Prior to the use of plastic, the normal life of a firebrick roof was approximately 12 months with considerable repairs and patching during this period. With a rammed plastic installation, we now have a roof with a life expectancy of approximately 24 months, with no repairs other than periodic gunning to retard the spalling of anchor tile and to fill erosion spots resulting from normal combustion velocity.

In our mill, as in others, in order to improve the performance and reduce costs of processing units, and in some instances to remain competitive, it was necessary to increase the weight of slabs rolled. The width of our furnaces was 216 in. inside. We were already ordering the maximum slab length to conform to this width, and the only way we could increase the tonnage would be by ordering thicker slabs. The thickness was increased to the maximum that could be handled or broken down on the mill, and because we had only three furnaces, in many instances we found the increase in thickness resulted in furnace bottlenecks. In other words, the capacity of the mill was greater than the output of the furnaces. By replacing the original 18-in. fire brick walls with 10-in. plastic refractory walls, we will pick up an additional 16-in. in furnace width. This additional width will enable us to increase the length of the ordered slabs, reduce the thickness, and maintain present slab weights. This will definitely improve the heating performance and should result in an increase in the production rates of the bottleneck material.

We do not believe that we have come to the end of the line in plastic refractory installations, nor do we believe it to be a "cure-all." However, rammed plastics do have a place in our production program by providing greater furnace availability.

We have found that we can force our furnaces harder, secure greater output, and not have the fear—ever present—when using fired shapes, that we will have premature refractory failure.

DISCUSSION

PRESENTED BY

WM. J. WILHELM, Assistant Ceramic Engineer, Bethlehem Steel Co., Sparrows Point, Md.

ROBERT A. SMITH, Assistant General Foreman, Hot Strip Rolling, Jones & Laughlin Steel Corp., Pittsburgh Works Div., Pittsburgh, Pa.

EUGENE HOFF, Laclede-Christy Co., Div. of H. K. Porter Co., New York, N. Y.

E. E. CALLINAN, Superintendent Masonry and Labor, Alan Wood Steel Co., Conshohocken, Pa.

R. H. TURNER, Electrical Engineer, United Engineers & Constructors, Inc., Philadelphia, Pa.

JOHN A. WARCHOL, General Foreman General Labor, Lukens Steel Co., Coatesville, Pa.

FRANCIS WALSH, Assistant Superintendent Standards Mills, Saucon Plant, Bethlehem Steel Co., Bethlehem, Pa.

C. L. MERCER, Assistant Mechanical Engineer, Lukens Steel Co., Coatesville, Pa.

JOHN S. MORRIS, Supervisor, Construction and Central Maintenance, Lukens Steel Co., Coatesville, Pa.

R. M. RICHARDSON, Manager Advertising and Sales Promotion, The Ramtite Co., Chicago, Ill.

Wm. J. Wilhelm: I would like to ask Mr. Smith the following questions:

1. What is the operating tonnage of the furnace shown on the figures?
2. What quality plastic are you using?
3. Did I understand that you use a first quality hanger tile?
4. What quality gunning material did you use?
5. Have you any experience with centers other than 12-in.?
6. Would your experience dictate the use of a different plastic in the heating and soaking zones, or could you get away with using the same plastic in both zones?

Robert A. Smith: In answer to Mr. Wilhelm's questions: The operating tonnages of our furnaces are 210/220 tons per hour. They are rated at 100 tphr each. We use a special super duty grade of plastic, with first quality hanger tile.

We have used various gunning materials. Some from Butler Co., gunram #80 from Ramtite Co., and hi-alumina from Harbison Walker Co.

Our experience has been principally with 12-in. centers, although we did go to 13 in. on our last job, but it does not mean anything. The 13-in. center was used merely because we were using 12-in. insulation block and were able to fit it in between the T-bars more easily.

We have used the same grade plastic in the furnace, whether it be for roof, side wall or heating zone.

We have never done any experimenting with different grades in the different zones.

Eugene Hoff: I wanted to ask Mr. Smith what provision was made for movement joints and at about what intervals. The author also spoke of heat-resistant alloy anchor bolts. I would be interested in knowing the type of anchor bolt he used.

Robert A. Smith: We are not making any provision for expansion joints in our plastic structure. We feel that with the moisture in the material along with the proper ramming density they are not necessary.

The anchor bolt that we use in the hot zone and soaking zone is a stainless grade. It is inconel hi alloy. In the cold zone a low carbon steel nut and bolt can be used instead of the steel T-bars such as we use.

E. E. Callinan: You mentioned going to the 7-in. thick roof from the 9-in. Would you describe your insulation practice under both conditions, that is, did you add insulation, when you went to the thinner roof?

Also, with respect to going to the thinner roof, did you do that simply because of the economics, or was it to get the added two inches of height inside your furnace, or from the standpoint of life? I would be interested in knowing if you have had specifically unfavorable experiences or specific troubles with respect to the spalling of the hanger tile.

I happen to be experiencing some of that. Nothing has happened detrimental to the roof up to the present time, but I wondered what eventual trouble might be expected.

Robert A. Smith: We did not apply any insulation to the 9-in. roof nor do we use any on a 7-in. roof. We do not insulate because we would trap the heat in the material and perhaps burn out the 3-in. I-beams that are bolted to the bottom flange of the main roof beams. The bottom flange on the 3-in. beams must be air-cooled.

No, we did not go from a 9-in. roof to a 7-in. roof because of the economics of it, nor did we change in order to get the added two inches of height inside of the furnace. The savings would have been negligible and the added height could have been picked up by raising the main roof beams. However, we had a couple of bad experiences with the 9-in. roof where it shelled off in thin layers and we felt that a better job of curing could be done on a 7-in. roof. This has proven itself.

We have had some spalling of anchor tile, but not too much trouble with it. One must provide good maintenance and inspection from week to week. You have to plan the maintenance, particularly for the roof. Keeping the spalls or crevices filled with a gun material greatly improve the performance of the roof.

R. H. Turner: I would like to have a little more information on the method of construction of the roof. How thick a layer do you apply before you ram? Do you have any difficulty with fracture of the anchor tile during ramming operation?

Robert A. Smith: We ram horizontally on the roof using blocks of plastic material 7 × 12 × 3 in. thick. When material has been rammed to a hanger, the anchor tile is set into the plastic and more material is rammed in and around it. As for breaking any of the necks off on the hangers, I do not know that we ever have. It is no problem for us.

John A. Warchol: I would like to know who does the installation of these roofs and side walls; and on your arches, do you take any special precautions? Do you have any trouble in your doorways? Do you provide any expansion joints in your work?

Robert A. Smith: I might say that unfortunately we started out using masons. They are still doing the job. I would recommend that you have it done by the labor department with brick department supervision, if possible. It would be a lot cheaper. Better yet, set up a new job as "plastic rammer."

No, we do not have any trouble with arches or doorways nor do we allow for expansion.

Francis Walsh: I would like to ask Mr. Smith if the holes that you put in for drying out are done from top or bottom and how deep are they?

Also I would like to know if you have experienced any difference in life of roof using different types of fuel.

Robert A. Smith: We are perforating from both the top and the bottom and the majority of the holes are clean through the material.

Our experiences in the life of a roof using different types of fuel is limited. We are using a mixture of coke oven and natural gas supplemented with tar. We believe that the plastic would stand up much better with only gas as a fuel. However, in our furnaces tar is necessary and with the flame temperature such as it is, it is very rough on refractory. Also tar can be very rash if not controlled properly

C. L. Mercer: I would like to congratulate you on your four-years' average life on your furnaces.

I would like you to describe the design of the bull nose, as we call it—the transition from your furnace door to your roof. What is the design of that area on the front door furnace? We call it "bull nose"—the metal roof.

Robert A. Smith: We are not using plastic material in that particular part of the furnace so I am sorry I cannot help you.

John S. Morris: I would like to ask Mr. Smith if they have had any experience with plastics in furnaces other than preheat furnaces. In other words, have they made use of plastics in other furnaces such as open hearths, soaking pits, etc.?

R. M. Richardson: Our first installation at the Pittsburgh Works of Jones & Laughlin was in a soaking pit cover in July 1947. Soon after this work, we constructed a burner wall and a side wall around the discharge and observation doors in a bloom heating furnace.

Next, we installed the roof and side walls in the heating zone of a double fired billet heating furnace. Then we went to the strip mill and installed burner walls and complete 10-in. side walls in all three furnaces with flat roofs in the hot zone down the slope to the bottom knuckle. The 10-in. side walls provide a wider furnace which will take longer slabs and show increased production.

From the strip mill, we went to the open hearth and installed several plastic fantails and noses, then flat arches over dutch oven extensions in several boilers burning pulverized coal.

After that, we rebuilt a number of railway spike furnaces, forge furnaces and other smaller furnaces around the mill.

By
VERNON W. JONES
Superintendent Steel Production
Armco Steel Corp.
Middletown, Ohio

Figure 1 — General view of north runway in scrap preparation yard.

PREPARATION OF SCRAP FOR OPEN H

. . . . proper scrap preparation may be an important factor in increasing open hearth production rates. . . . each four minutes saved in charging time saves one minute of subsequent furnace operating time. . . . benefits also pyramid. . . .

▲ THE present day production of most of the open hearth shops of the country exceeds the tonnage for which the shop was designed. This puts a premium on operating space. As the major part of the work performed in an open hearth shop is in the movement of materials it becomes increasingly important to use the available space as efficiently as possible. Heavy scrap makes it possible to use fewer charging pans and charging buggies than would be required if the scrap were bulky and light in weight so the need for better preparation increases as the tonnage increases from a given unit.

In addition to the increase in weight per pan, scrap preparation plays an important part in quality control. The tramp metals are removed and scrap is sorted by grades, i.e., copper bearing and nickel bearing. This is important with the present day metal market.

At the Middletown works of the Armco Steel Corp., a scrap preparation yard became necessary to relieve the congestion in the open hearth stockyard which had not been increased in proportion to the increase in production. Therefore a scrap preparation yard was erected to handle domestic and purchased unprepared scrap.

The scrap preparation yard covers an area of 15 acres and consists of two crane runways, each 825 ft in length. There are five 7½-ton overhead cranes, two on the north runway and three on the south runway. Under these runways there are placed 16 alligator shears and a hydraulic bundler. There are four No. 4 shears, four No. 3 shears and eight No. 2 shears. A 25-ton locomotive is used to transfer cars of scrap on the several tracks required for storage of prepared and unprepared scrap. A 40-ton diesel crane is used to load and unload scrap i· yard outside of runways and for dismantling scrapped locomotives and railroad cars. There is a track scale for weighing inbound and outbound material.

Figure 1 is a general view of the north runway. Miscellaneous No. 2 sheet scrap is seen in the foreground. This scrap is received in trucks and cars which are unloaded with the overhead crane and sorted as to heavy and light gage. The scrap iron that is too heavy for bundling is put on a separate pile, resheared or burned to charging pan size. The light gage No. 2 sheet scrap is also put on a separate pile, and when a carload is accumulated, it is sent to open hearth to be bundled. A carload of enameled scrap is shown in right foreground. This scrap is sheared on two No. 2 shears in this runway. In the background there are four No. 2 shears for shearing heavy scrap and pipe. These shears are located in the middle of the runway due to the necessity of the scrap being handled with a crane.

Figure 2 — Scrap pipe is prepared by cutting to about 6-ft lengths.

Figure 3 — Ten shears are operated in this runway.

Figure 4 — Coil ends of cobbles are sheared on No. 3 shear.

Figure 5 — Bundles from this baler are produced at rate of 5 tons per day.

HEARTH FURNACES

Figure 2 shows scrapped pipe being prepared for shearing. A carload of scrapped pipe is unloaded by a crane under the runway. Enough pipe is distributed on the ground by means of a crane to keep work ahead of the burners. All pipe is cut to approximately 6-ft lengths. It is necessary to split all pipe over 6 in. in diam into two or more pieces in order to get it under the shear blade. Shearmen pick up the split pipe and put it on the gravity conveyer ahead of the shear. Pipe is sheared to 18 in. or under in order to get heavier weight per open hearth charging pan.

Figure 3 shows the general view of the south runway. The bundler building and clip stock are in the foreground. Four No. 3 shears and six No. 2 shears are operated under this runway. Miscellaneous prepared scrap iron is received in trucks and unloaded in this yard with a crane. When a carload of scrap is accumulated, it is loaded and sent to the stockyard.

Unprepared scrap iron is sheared on the No. 3 shears under south runway. It is sorted as much as possible when unloaded by a magnet. The scrap iron which is too heavy for shearing is sent to the area in the center of the runway where it is cut with a burner to charging pan size. Space is reserved under this runway for preparing current heavy material. Miscellaneous unprepared scrap is stocked ahead of shears with a crane. The shearman sorts out the undesirable nonferrous metals, cast iron and light gage scrap. It is necessary for the shearman to handle every piece of scrap iron. Only a portion of this scrap has to be sheared to charging pan size.

Figure 4 shows coil ends of cobbles being sheared on No. 3 shear, and Figure 5 shows finished bundles from the baler. The bundles are 14 x 18 x 22 in. and weigh approximately 300 lb. The baler produces bundles at the rate of 5 tons per hr. Very light gage scrap iron, such

Figure 6 — Domestic scrap which cannot be compressed is strapped in forms as shown.

as clips, used autos, etc., is charged into baler with a crane. Bundles are also loaded into cars with a magnet.

Fifty-four men are required to operate the scrap preparation yard, one 8-hr turn, five days per week. Approximately 8300 net tons of scrap are burned, sheared, pressed or sorted for the mill each month. An average of 1.14 manhours are required to prepare each ton of scrap.

The domestic scrap originating in the plant consists of barcrops, coil ends, sheet scrap, side and end shearings. The bar crops are extremely good scrap, but the other types of scrap must be prepared at the source or compressed into bundles.

Domestic scrap, not subject to compressing, is packed and strapped in forms at the source and delivered to the stockyard as shown in Figure 6. These bundles are 18 x 24 x 72 in. and average 3000 lb. Bundled sheet scrap is loaded into interplant trucks and sent to the stockyard. The bundles are loaded on piling blocks and spaced about six in. apart to avoid breakage when unloading with magnet in stockyard. Bundles are loaded into pans on buggies with a magnet as illustrated in Figures 7 and 8.

When the Middletown plant of Armco went into operation at the turn of the century it was, and still is, a completely integrated steel plant. Starting with scrap and pig iron the end product was roofing, gutters, downspouts and related products. The product today is expanded considerably but so far as scrap is concerned it is relatively the same.

The nature of the product resulted in most of the domestic, or revert scrap, being of very poor physical quality, as far as charging into open hearth furnaces was concerned. This was before the day of hydraulic bundling machines.

The problem was handled for several years by placing charging pans at every shear in the mill. These pans were loaded by hand by the scrap man on each shear. When loaded, the pans were placed on special pan cars and sent to the open hearth stockyard where they were transferred to charging buggies. This scrap averaged 500 lb per pan, 25 lb per cu ft.

At that time the scrap market was such that sheet clips were in the same price class as machine shop turnings. Clips were an excellent scrap from the analysis standpoint but were very light in weight. As Armco

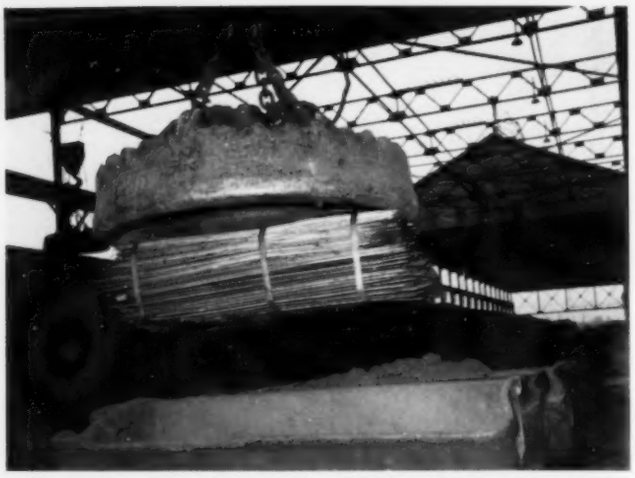


Figure 7 — Magnet is used to load scrap into buggies.

Figure 8 — Loaded buggy is shown with domestic scrap which cannot be compressed.

had a certain obligation to their customers, there was an excess of light scrap over and above our own production of revert scrap.

This problem was handled by building a large mechanical bundler in 1916. This machine, when there were plenty of annealed sheet clips available, made bundles weighing as much as 4000 lb each, 167 lb per cu ft. That meant only three buggies to charge 48,000 lb of scrap instead of the previous number of 24 buggies for the same amount of hand loaded sheet scrap.

This mechanical bundler is also used to bundle what we call fluffy turnings. With a certain amount of soft sheet clips it is possible to make a bundle from turnings that will run as high as 125 lb per cu ft instead of the extremely light weight of a pan of turnings loaded directly into charging pans with a magnet.

Cars of domestic scrap are alternated with purchased sheet clips on the supply track to this machine. The machine is serviced by a 15-ton overhead crane with a 65-in. magnet. The bundles are delivered directly into special charging pans by the machine. There is a three-man crew operating this machine which produces about 15 tons per hr.

In later years, after the scrapyards started installing hydraulic bundling machines, it became almost impossible to purchase annealed clips in the open market so the machine does not have the value that it had 39 years ago. In its time, it was probably the greatest advance ever made in scrap preparation.

Figure 9 — Bundle shown has just been prepared in hydraulic bundling machine.

Figure 10 — Four bundles are loaded on buggy.

Figure 9 shows a bundle emerging from the machine and Figure 10 shows a buggy loaded with four bundles.

Miscellaneous domestic scrap, such as pit runner scrap and ingot butts are shipped directly to the stockyards. Scrap too bulky to charge, of course, is first prepared in the scrap preparation department. Steel buttons are cut to size at a button cutting station locate in the scrap preparation yard. The burner is set up on a small trolley which operates on a 5-ft runway. The burner travels in any direction. Cutting speeds average from one to three in. per min, depending on the thickness and the cleanliness of the steel being cut. Buttons are cut up to 40 in. thick.

The amount of labor that can be used in scrap preparation is governed by the amount of furnace operating time that can be saved.

Numerous studies of the factors affecting open hearth production rates have been made and in each of these studies the time of start charge-to-finish charge of scrap has shown up as one of the major factors. A study made in 1945 showed that each four minutes reduction in charging time saved one minute of subsequent furnace operating time. In that shop, the charging time per buggy of scrap averages four minutes. The time from start charge to the addition of the first hot metal has a greater effect on heat time than the total scrap charging time. The scrap charging time has a direct effect on the hot metal time, so the benefits pyramid.

Long trains of scrap cause operating delays to furnaces other than the furnace that is being charged. The effect of this variable has never been studied by statistical methods but it can readily be seen by observation that long trains decrease production.

DISCUSSION

PRESENTED BY

J. W. DeWITT, Superintendent Yard Dept., Bethlehem Steel Co., Bethlehem, Pa.

VERNON W. JONES, Superintendent Steel Production, Armco Steel Corp., Middletown, Ohio

J. A. BELL, Chief Engineer, Bethlehem Steel Co., Bethlehem, Pa.

W. C. SCHULZ, Superintendent Power and Maintenance, Bethlehem Steel Co., Steelton, Pa.

M. B. ANTRIM, Assistant Manager, Maintenance and Construction, Lukens Steel Co., Coatesville, Pa.

CHARLES T. MAZZA, General Foreman, Bethlehem Steel Co., Bethlehem, Pa.

R. M. DENGLER, Assistant Superintendent Yard Dept., Bethlehem Steel Co., Bethlehem, Pa.

J. W. DeWitt: I was very interested in your bundling. Do you find that those bundles hold together well? Are they compact enough for rehandling or do you have to take them directly to furnaces?

Vernon W. Jones: You have to take them directly to furnaces.

J. A. Bell: Referring to one of the pictures of the stockyard, you stated that the scrap was brought in by rail and by truck. Does it pay to handle scrap by truck in such a congested yard?

I wish Mr. Jones would describe in a little more detail, the feeding of the scrap into the shear and the manner of charging into the charging boxes. Is the scrap fed into the shear by some electrical or hydraulic pusher?

Is there a clamping device by means of which scrap is prevented from jumping out of position on the feed table?

Where you have your bundling operation, is it possible to charge bundles directly into the charging boxes without resorting to additional manual handling?

W. C. Schulz: In your burning operation, do you use LP gas or acetylene?

Do you have any car sides to shear, that is, as full sides of cars? As you know, they are quite a job to handle. Do you have to burn them first, or is cold shearing used only to get them to charging size?

M. B. Antrim: I have a question concerning the segregation of copper, tin, lead, aluminum, etc. Please explain how the people in the scrapyard do that job, including facts concerning whether they are paid on an incentive for doing it, and the method used of getting these residuals out of the charge?

Charles T. Mazza: What are your precautions in the preparation of scrap, to prevent harmful effects to the men while burning scrap coated with a lead base paint?

R. M. Dengler: Have you given any thought to the guillotine type shear for handling your scrap, and what type would you get, if so?

From the pictures I do not believe you had any holddown devices to keep the scrap from flying. Is that a problem in your yard?

Vernon W. Jones: The first question was on manhours per ton. Maybe I did not make that plain enough. It takes 1.14 manhours per ton to prepare the scrap. It would be hard to figure the cost of scrap preparation from that. For instance, last year, the total amount of alloys recovered, such as lead, brass, copper, and so on, was a little over 81 tons, but we get no credit for that in our scrap preparation costs. But the manhours have been 1.14 per ton.

The bundles cannot be stocked; they have to go straight to the furnace. In fact, they break a little on the buggy from the vibration. Occasionally they fall off. I did not want that in the picture.

This question of holding scrap under shears: We do have holddowns on some of the shears. They are not automatic; just holddowns built ahead of the shears so that the piece cannot fly. We also have tables, hydraulically operated, going up and down in front of some of the shears so that the man does not have to manhandle the heavy piece. We work the heavy pieces on the table that goes into the shear and the man just slides it in.

I must admit that the yard looks like a pretty jumbled up mess. However, the state of Ohio conducts a safety contest in the scrapyards of the state. Armco took over operation of the yard in 1942 and every year since that time, except for the years 1948 and 1952, this yard has won or tied that contest and they have won it by having no major injuries. We had a man that lost the end of a finger in 1948 and two major injuries in 1952 when a couple of men in the place got mixed up and put some oxygen into a tank that had oil in it. The place does look cluttered up but the fellows do a good job from a safety standpoint.

The gas we use is acetylene or natural.

No, we do not have very many car sides now. I think we have had about 80 cars of this scrap so far this year. Three years ago the place was full of them. We do have to cut the sides to size when handling them under a shear.

Most of the cutting is done by a shear.

Now, as to segregation of scrap—with the miscellaneous scrap that comes in; wrecked automobiles, and so forth—we put on quite a training program with the men in the yard, so that they know the various grades of scrap. They do a good job of sorting. We have two men in the yard whose sole duty it is to reclaim brass and copper, etc. If a piece goes into the shears with brass, copper or lead attached, it is thrown off to the side and sent to the two men who take it apart and reclaim it. It is up to the men to use their judgment if the piece is large enough to justify reclaiming in that way.

In addition we pay an alloy bonus to all employees that handle scrap in the open hearth stockyards. The two people that do not get the bonus are the two men working on the alloy reclamation job. The alloy bonus is paid to men in the stockyard, to the crane operators, men in scrap drop and the burners that burn the large pieces of scrap. Theoretically they throw that aside and do the work on their own after quitting time.

As to lead poisoning, this is the first time I have heard that mentioned. In wrecking locomotives we do reclaim a lot of lead but that is out in the open air, the fumes are taken up in the air and spread so thin that there has never been a case of lead poisoning from that. All scrap burning is done in the open air.

There has been a lot of talk about the guillotine-type shear. I saw some of those shears in operation in a scrap preparation yard, and it is a very efficient machine, but whether the cost of the guillotine shear is justified in ordinary scrap preparation is still a question.

This reclamation of alloys in alloy bearing scrap is growing more important every day, and the scrap dealers are beginning to do something about it. They are doing something from the viewpoint that they can get more money from the alloy bearing types of scrap. That is going to be of help to everybody. We do not want to put nickel or copper bearing scrap in heats that do not need the alloys. Conversely, we need any amount of these alloys that can be reclaimed from scrap.

W. C. Schulz: Do you have purchased bundles brought into your plant, and if so, how do you examine them for contamination?

Vernon W. Jones: We had a little trouble with contamination for a short time when we were going outside of our area buying No. 2 bundles. It got so bad once that we could not use the bundles in the electric furnaces because we would burn the electrode holders.

You have probably seen our figures on yields as reported at National Open Hearth Committee meetings. Some were as low as 70 per cent yield—the rest was concrete, ashes, etc. But we have not had trouble lately as our purchasing of No. 2 bundles is restricted to dealers in our immediate area—these fellows are making a decent No. 2 bundle. However, we do periodically pick random cars and blast the bundles open for inspection purposes.

There is constant demand for copies of "The Modern Strip Mill," published by the Association of Iron and Steel Engineers. If your copy is not in use please get in touch with us.

ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

. . . . there is a very definite trend to the application of automatic devices on rolling mills . . . . presetting screw position and relative speeds is a logical first step in converting a reversible hot mill to automatic operation . . . . card reading systems or preset schedule boards can be used . . . . a simple and quick method is necessary for setting up new schedules . . . .

Preset Screwdown Control of Reversing Rougher at Granite City Steel Co.

By

A. W. SCHLECHTE

Chief Electrical Engineer

Granite City Steel Co.

Granite City, Ill.

and

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Control System Engineer

The Electric Controller and Manufacturing Co.

Div. of Square D Co.,

Cleveland, Ohio

▲ GRANITE City Steel Co.'s 90-in. hot strip mill was built in 1936. Economic conditions and limited open hearth capacity precluded the installation of a full continuous strip mill. An existing three-high plate mill, with the addition of vertical rolls driven from the same gear reducer, was used as a roughing mill to break down the slab to a thickness suitable for rolling on the four finishing stands. A fifth finishing stand was installed in 1940. The capacity of the roughing mill was increased by a gear change on the drive and the installation of side-guides on the front and back tilting tables. This mill was driven by a 3000-hp wound rotor motor and approximately 100 tons per hour was capacity.

In 1951 an expansion program was started which included additional open hearth capacity and a modern high lift slabbing mill. To increase the capacity of the hot strip mill it was decided to install a modern four-high reversing roughing mill with ample power. A close coupled edger was included. The horizontal rolls are direct driven by two 3500-hp motors. The vertical rolls are driven by one 1000-hp motor. Edging is done only on the odd passes.

Automatic operation of the screwdown and edger adjustment was considered as being essential to gain greater accuracy in the thickness and width of the bar delivered to the finishing stands. This control has been in operation since September, 1953, and has been quite successful. Variation in thickness of the bar is less than 0.010 in. on a bar thickness of from 1.000 to 0.500 in.

The number of slabs rolled per hour indicates that the speed of operation is fast enough. Over 60 slabs using five passes have been rolled per hour. Thinner slabs rolled in three passes have been rolled at a rate of 90 per hour. The maximum number of slabs rolled in one eight-hour turn was 424, the maximum tons in one turn 2725. The operating people believe that this could not be done with manual control and maintain accurate gage. In the interest of gage and quality control, the operating department has established a policy of not rolling if the automatic equipment is not operating properly.

The pass indicating light circuit is used to signal the furnace pusher and furnace table operators when the last pass is being made. On the third pass the indicating light circuit is used to initiate recording of temperature of the slab being rolled.

The integrated automatic controls for this 4-high reversing-roughing mill include automatic preset screwdown controls for the horizontal rolls and the vertical edger rolls, and automatic short-travel limit switch control for both the front and back side-guides. Figure 1 indicates the mechanical layout of this mill. The screw-

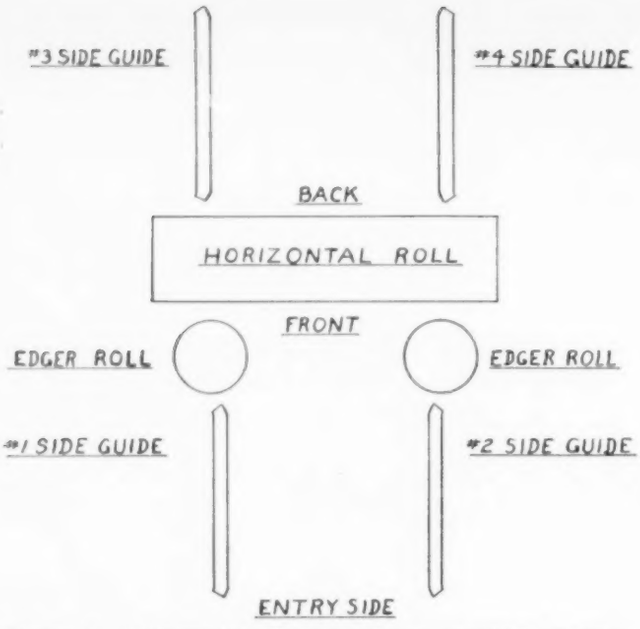


Figure 1 — Schematic diagram shows physical arrangement of rolls and side guides.

down motors for the horizontal rolls are two 75-hp compound-wound motors with full load speeds of 515 rpm geared to provide a screwdown speed of 34.3 in. per min. The vertical edger screwdown motor is a 50-hp, compound-wound motor with a full load speed of 550 rpm, geared to provide a screwdown speed of 132 in. per min. total change of roll opening. The four side guides are independently driven by 10-hp compound-wound motors.

Under normal operation, the positioning of both sets of rolls, as well as the side guides and speed control of the edger roll drive motor, are determined from a preset schedule, which may include as many as 15 passes. Two separate and readily changed schedules are supplied. Automatic position control of the horizontal roll can be set in increments of 0.025 in. over a control range of from 0 to 9.975 in. Automatic position control of the edger rolls can be set in $\frac{1}{8}$-in. increments over a control range of from 22 to 93$\frac{7}{8}$ in. The side guides are adjusted for a normal movement of two in. each, thereby giving a total change between guides of four in. In addition to the position control, there are provisions for any one of five speed control signals corresponding to 10, 20, 30, 40 and 50 per cent reduction between the horizontal and vertical roll drive motors.

OPERATION

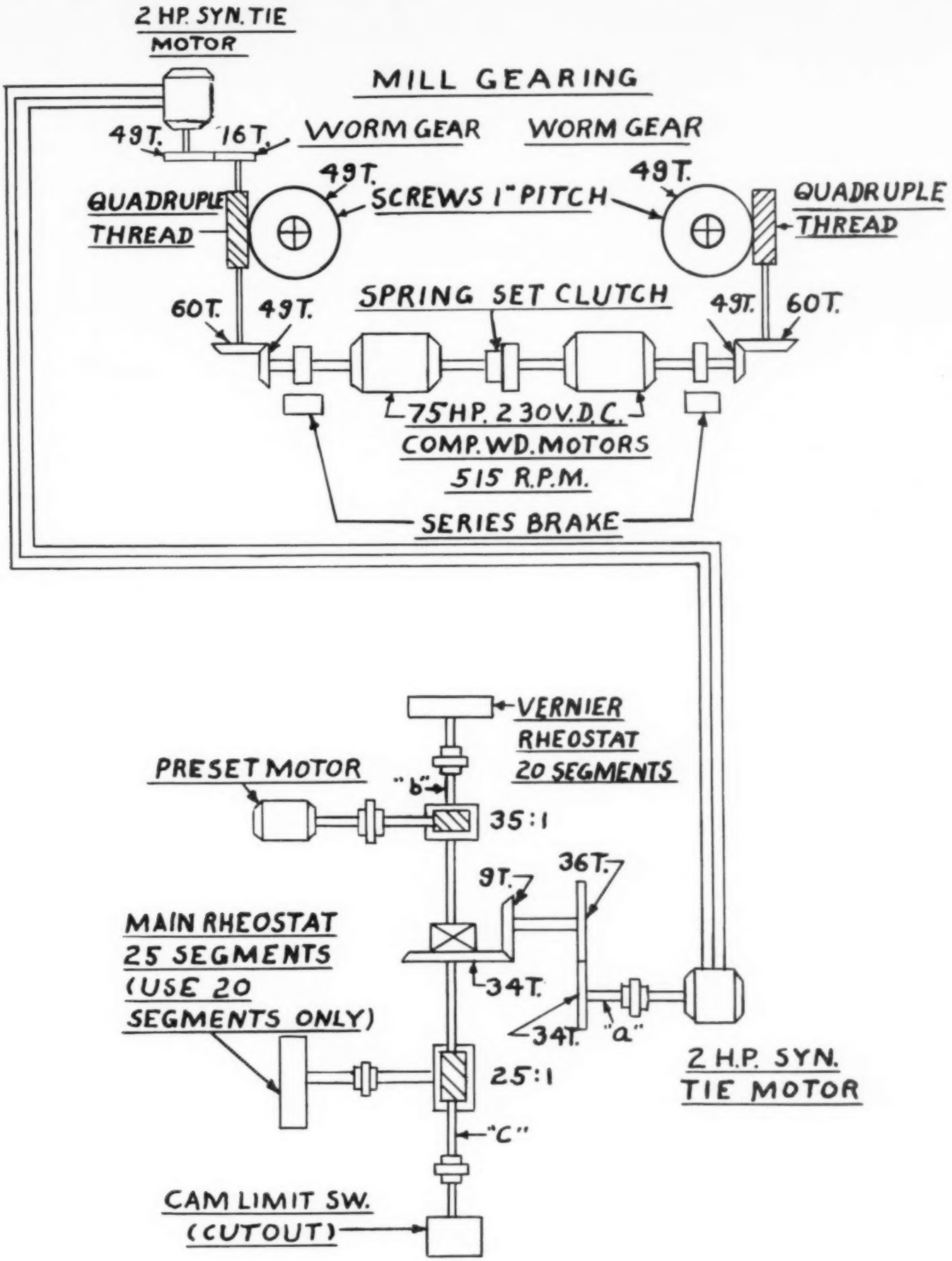
To describe the operation of the screw-down controllers, it will first be necessary to show how the roll position-indicating means is tied to the screwdown drive. The differential cutout assembly for the horizontal roll position controller is shown in Figure 2 along with the gearing of the mill screwdown. It consists of synchronous-tie receiver, a differential gear assembly, a small setup motor, a cam limit switch, suitable gearing, a 25-segment main rheostat and a 20-segment vernier rheostat. The synchronous-tie transmitter is mechanically coupled to the screwdown motor through appropriate gearing.

With the setup motor deenergized, any up or down movement of the mill rolls will cause a displacement of the contact arm of the main rheostat and the cams of the cam limit switch. Because of the locking action of the 35 to 1 gear reducer between the setup motor and the differential shaft, the vernier rheostat arm will not be displaced. Movement of the screwdown motor is under control of the main rheostat and the cam limit switch only.

With the setup motor at rest, the angular movement of the main rheostat arm is related to the change in roll separation, in this case $\frac{1}{2}$-in. of roll separation corresponding to one segment on the main rheostat. The cam limit switch is so geared as to make one complete revolution as the arm of the main rheostat moves from the center of any segment to the center of an adjacent segment. Therefore, one revolution of the cam limit switch also corresponds to $\frac{1}{2}$-in. of roll travel.

With the screwdown motor idle, the setup motor drives the vernier rheostat, the main rheostat, and the cam limit switch, since the mill holds the shaft "a" fixed through the synchronous-tie motors. Under this condition, shaft "b" rotates at the same speed as shaft "c," but in the opposite direction. The maximum movement of the vernier rheostat arm is limited to $\frac{19}{20}$ of a revolution, corresponding to the angular distance between the center of its first segment and the center of its last segment. Thus, operation of the setup motor moves the main rheostat arm and the cam limit switch backward or forward, a fraction of a main increment. Operation of the setup motor is entirely under control of the vernier rheostat and the preset schedule. The vernier part of the schedule is a vernier adjustment in the final positioning of the rolls. The main rheostat is used in conjunction with the cam limit switch in controlling the direction and speed of the screwdown motor in accordance with a preset schedule on the main part of the schedule panel. The vernier schedule panel controls the final position of the setup motor through the vernier rheostat. Thus, the actual separation for any pass must be set up on the schedule panel as the sum of the main and the vernier increments. The purpose of the differential gearing and the setup motor is fundamentally that of reducing the number of selection schedule points on the schedule panels.

Figure 2 (right) — Horizontal roll position drive gearing and preset control differential unit. Total gear reduction equals 49/60 x 4/49 equals 1/15 or 15:1. Vernier rheostat has 20 segments at 0.025 in. equals 0.5-in. roll travel. Main rheostat has 20 segments at 0.5 in. equals 10-in. roll travel. Total movement under automatic preset control equals (19 x 0.5 in.) + (19 x 0.025 in.) equals 9.975 in. One reversing of screwdown motors equals 49/60 x 4/49 equals 1/15 roll travel. One in. roll travel equals 15 revolutions of motors. Fifteen revolutions of motors equals 15 x 49/60 x 16/49 equals four revolutions of synchronous tie motors. Four revolutions of synchronous tie motors equal 4 x 34/36 x 3/34 x 2/1 (differential factor) equals two revolutions of cutout equals one in. roll travel. One revolution of cutout equals 1/2-in. roll travel equals one revolution of vernier rheostat equals one segment of main rheostat.


2 HP. SYN. TIE MOTOR
MILL GEARING
49T.
16T.
WORM GEAR
WORM GEAR
49T.
SCREWS 1" PITCH
49T.
QUADRUPLE THREAD
QUADRUPLE THREAD
60T.
49T.
SPRING SET CLUTCH
49T.
60T.
75 HP. 230 V.D.C. COMP. WD. MOTORS 515 R.P.M.
SERIES BRAKE
VERNIER RHEOSTAT 20 SEGMENTS
PRESET MOTOR
"b"
35:1
9T.
36T.
MAIN RHEOSTAT 25 SEGMENTS (USE 20 SEGMENTS ONLY)
34T.
34T.
"a"
2 H.P. SYN. TIE MOTOR
25:1
"C"
CAM LIMIT SW. (CUTOUT)
PRESET CONTROL DIFFERENTIAL GEARING

ELECTRICAL INTERPRETATION OF ROLL SEPARATION

Figure 3 shows a 20-segment rheostat along with a portion of a 15-pass schedule panel and the necessary stepping relay. Nineteen identical resistors are connected in series across the segments of the rheostat to form a potentiometer. An a-c voltage is connected across this potentiometer. The 20 segments of the rheostat are connected to 20 horizontal conductors which make up part of the schedule panel.

A stepping relay, only one level of which is shown here, has its operating coil so connected in the control circuits that upon completion of the roll travel to any preset position, it automatically steps its contact arm forward to the next stationary vertical slide bars of

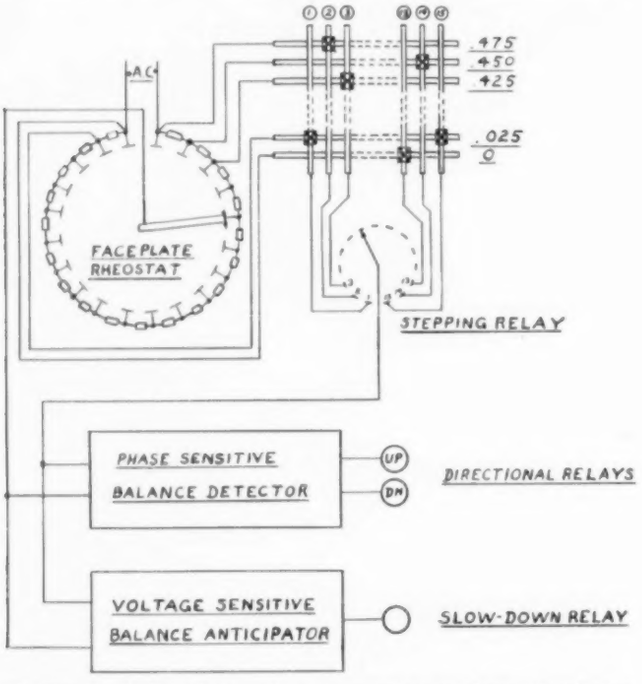


Figure 3 — Rheostat and error sensing system illustrates connections to slider schedule panel.

the schedule panel. The sliders on these schedule panels serve to connect the vertical cross bars to the desired horizontal increment bars.

In the case of the setup motor control, this new position of the stepping relay arm on the vernier level immediately results in the vernier rheostat being driven to the position called for by the vernier section of the schedule panel. At the same time the stepping relay, through its "main" level, sets up the necessary circuit for the movement of the screwdown motor to its next position. Such movement does not occur until the operator presses the operating push button after the steel has left the rolls at the completion of a pass.

Also on Figure 3, are shown two block diagrams indicating a phase-sensitive balance detector circuit and a voltage sensitive balance anticipator circuit. The phase-sensitive circuit is arranged so that, with no signal input, neither of the output relays will be energized. With a signal input, one or the other of the output directional relays will be energized, depending upon the phase of the input signal. The voltage sensitive balance anticipator circuit is arranged so that the slow-down relay in its output circuit will be energized only when the input signal is below a certain preset magnitude. The balance detector circuit relays are used to control the direction of the motor under control, and the balance anticipator circuit is used to control the speed of this motor. This system is then seen to be a follow-up system where the motor operates to reduce the error signal existing between a point on the rheostat selected by the rheostat arm and a desired point on the rheostat as selected by a slider on the schedule panel for some particular pass. The controlled motor is caused to move at high speed until the error is reduced to a small value, at which time the balance anticipator circuit functions to cause the motor to slow down to prevent over-shooting.

The control of the set-up motor is simple because of the constancy of the inertial and frictional characteristics of the system which it drives. By suitable adjustment of the balance anticipator, along with the armature shunt resistor which it controls, and by proper selection of a final dynamic braking resistor introduced when the edge of the balance segment has been reached, it is very easy to stop the set-up motor consistently with the arm of the vernier rheostat at the center of the proper segment.

For control of the screwdown motor, the same fundamental system is used except that final positioning is accomplished with the cam limit switch. The control is so arranged that when the system reaches electrical balance on the main rheostat, the control is turned over to the cam limit switch, which maintains the directional power to the motor and brings in another step of armature shunt followed by removal of power from the motor just before the center of the desired segment is reached. At this time, a series brake is also set. Should the rolls overtravel the desired position, the motor will be plugged under the control of either the up or down cam, according to the direction of motion. The screwdown motor always stops with the arm of the main rheostat in the center of the proper segment.

When the screwdown motor stops, a signal is applied to the stepping relay, causing it to index, thereby setting up a signal for the next movement of the rolls. Upon completion of the last pass for a schedule, the ratchet relay is caused to quickly return to its initial condition, thereby setting up for the first pass again. The stepping relay for the horizontal roll position controller also includes one level for control of the edger roll drive motor speed. This signal is also preselected on the schedule panels, and its purpose is to correlate the speed of the edger rolls with the speed of the screwdown horizontal rolls for the reduction taken on odd passes.

Control equipment for the positioning of the vertical edger rolls is very similar to that for the horizontal rolls. The main difference is in the differential gearing, which is indicated in Figure 4. The stepping relay associated with this controller also includes signals which are fed to the side guide controllers for "in" and "out" positioning of the side guides.

THE SCHEDULE SELECTOR PANELS

The schedule selector panels are mounted near the operator so that he may select the proper schedule and

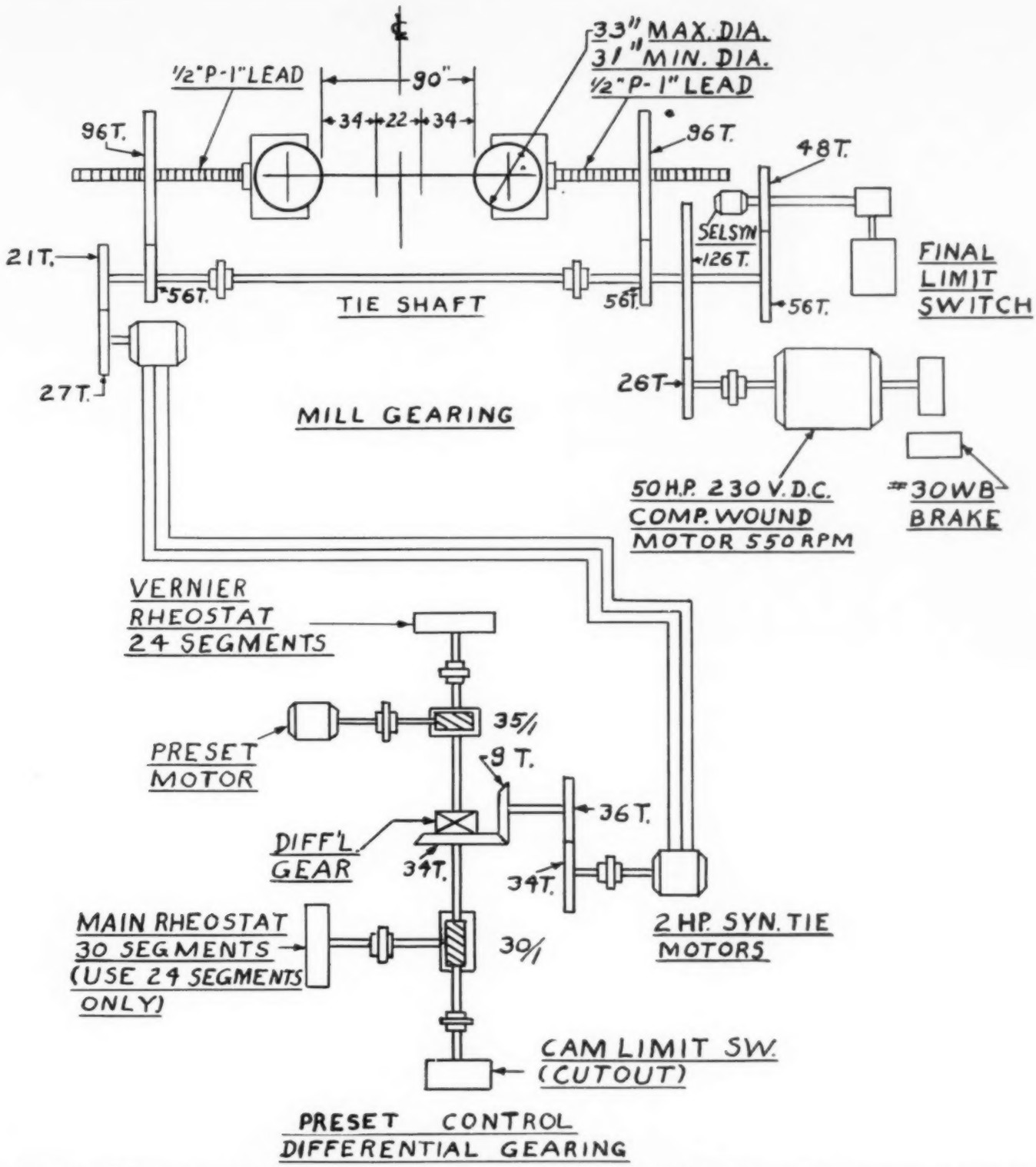


Figure 4 — Edger roll position drive gearing and preset control differential unit. Vernier rheostat has 24 segments at 1/8-in. total roll separation equals 3-in. roll separation. Main rheostat has 24 segments at 3-in. total roll separation equals 72-in. roll separation. Total roll separation under automatic preset control equals (23 x 1/8) + (23 x 3) equals 71-7/8 One revolution of edger motor equals 26/126 x 56/96 x 1 in. x 2 equals 13/54-in. roll separation. One-in. roll separation equals 54/13 revolutions of motor. Three-in. roll separation equals 162/13 revolutions of motor. 162/13 revolutions of motor equals 162/13 x 26/126 x 2 1/27 equals two revolutions of synchronous tie motor equals three-in. roll separation. Two revolutions of synchronous tie motor equal 2 x 34/36 x 9/34 x 2/1 (differential factor) equal one revolution of cutout. One revolution of cutout equals three in. roll separation equals one revolution of vernier rheostat equals one segment on main rheostat.

change schedules to suit rolling requirements. Figure 5 shows the dead-front schedule panels. All sections of the slider units are provided in duplicate so that two completely isolated schedules may be set up at one time. Each complete schedule consists of a main and vernier slider unit for the horizontal rolls, a main and vernier slider unit for the edger rolls, an edger roll drive draft compensation slider unit, and a final pass selection

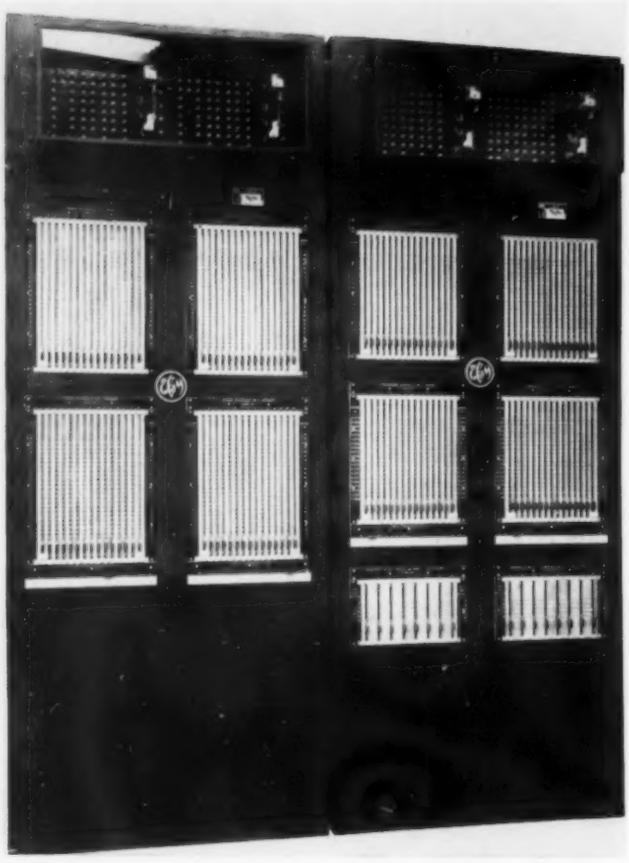


Figure 5 — Schedule panels for two complete schedules show adjustable sliders and schedule selector switches.

slider. At the top of the panel are mounted the stepping relays. Below these relays are the pistol-grip switches which are used to transfer control from one preset schedule to the other. Each individual slider unit of the schedule selector panel has a horizontal scale indicating the pass numbers from 1 to 15 with a single adjustable slider under each pass number. These sliders can be moved up or down to settings corresponding to the vertical scales located at the side of each unit.

SIDE GUIDE CONTROLLERS

There are four 10-hp reversing non-plugging dynamic braking controllers for these drives. The side guides are stopped in the "full out" or "full in" positions by over-all or final limit switches. Stopping is accomplished by opening motor circuits, applying dynamic braking and setting the magnetic brakes. In addition, each drive is equipped with a short-travel cam limit switch. Each of these limit switches has a spring-set, magnetically released clutch, whereby the switch may be clutched to the drive at any desired position for the width of the plate to be rolled. These limit switches control two in. of movement of each of the side guides, or a total of four in., in and out. Stopping of the motors by the short-travel limit switches is accomplished by slow-down on armature shunt, opening the motor circuits, applying dynamic braking, and setting the brakes.

Normal operation of the side guides is automatically controlled from the stepping relay associated with the vertical edger roll position controller. In this case, for odd numbered passes, the front guides move in for proper rolling position and the back guides move out for clearance; and for even numbered passes, the back guides move in and the front guides move out for clearance.

For emergency and for setup purposes, other methods of control are also available. Should the automatic control become inoperative, the operator can simultaneously operate the four side guides by a selector switch mounted on his control desk. In the case of an emergency, the operator may desire to fully open all of the side guides simultaneously. This may be readily accomplished by operation of another switch. For purposes of setting up for a new width, the side guides can be independently adjusted with the short-travel limit switches declutched. Returning the switch to the automatic position resets the clutch of the short-travel limit switches and allows automatic movement of the guides in and out over the desired range.

INTEGRATED OPERATION OF ALL POSITION CONTROLS

Normal control of the movement of the rolls and side guides is obtained by operation of the push buttons and master switches located at the control desk. A series of pass-indicating lights are used to indicate when the control equipment is ready to set up the mill roll for a pass. When a proper indicating light is on, the operator may push the "normal operate" button for that pass, thereby initiating all necessary movements. When the light goes out, the rolls are in a position for the operator to pass the slab through the rolls for that pass. Procedure is repeated on the following passes. In case of an emergency, operation may be taken away from the automatic control and assumed by manually operated master switches for all motions. To assume manual control, it is only necessary to operate the appropriate master switches, while for automatic control, it is necessary that the master switches be in their "off" positions.

A setup push button has been supplied for both the horizontal and edger roll controllers. Operation of this button simply ratchets the associated stepping relay around one step at a time each time the button is pressed and released, and is used when the automatic control has been interrupted for any reason. For example, if the first two passes were rolled under automatic control and a cobble occurred which required rolling passes No. 3 and 4 by manual control from the master switch, then the automatic control can be set up for the No. 5 pass condition by operation of the setup button, whereupon full automatic control can again be obtained by normal operation of the "normal operate" pushbutton.

Under normal operation, the operator will press the "normal operate" button just as the steel leaves the horizontal rolls in either direction. This will cause the edger and horizontal rolls to quickly move to their next preset position. When the horizontal rolls have come to rest, the speed relationship between the edger roll drive motor and the horizontal roll drive motor is set. When the edger rolls have come to rest, the side guides move. The steel may now be passed through the mill. At the

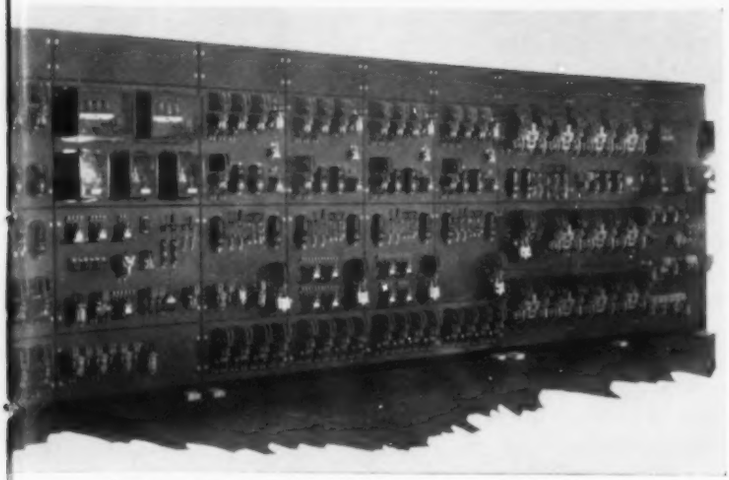


Figure 6 — Control panels for plate mill edger roll position, side guides and horizontal roll position are factory assembled.

end of this schedule, the entire system will return to its original condition and the equipment will again be ready for the first pass.

While rolling steel to one schedule, another schedule may be set up on the alternate schedule board. When it is desired to change to the new schedule, it is simply necessary to operate a schedule selector switch, making the new schedule operative and the old one inoperative, whereupon the old schedule may be changed.

Figure 6 shows the factory assembled control panel for all of the control functions described. The right section is for the horizontal roll screwdown, the center section for the four side guides, and the left section for the vertical edger screwdown. The power resistors are mounted on the angle iron framework behind the control panel. The differential assembly is located in a small room adjacent to the pulpit.

An interior view of the pulpit with the single operator at the control console, is shown in Figure 7. Foot masters are supplied for control of the tables and roll drive motors. With his hands, he operates the spray control and the "normal operate" button for the screwdowns and side guides.

Figure 7 — Control console and schedule panels are conveniently arranged in pulpit.

While this mill is not so equipped, a new type of programming is now available. This new system employs a punch card system where an entire rolling schedule can be prepunched into a 5 x 9-in. plastic card. The card is direct reading much in the manner of the presently supplied schedule boards. To roll to any schedule, it is simply necessary to place the appropriate card in the card reading instrument and proceed as before by momentarily depressing the "normal operate" button for each pass. This card reading system can be supplied as the sole means of automatic programming or in conjunction with the slider type schedule boards already described.

DISCUSSION

PRESENTED BY

C. C. THOMAS, Industry Engineering Div., General Electric Co., Steel Mill Div., Schenectady, N. Y.

B. R. KING, Assistant Superintendent, Electrical Dept., Inland Steel Co., Indiana Harbor Works, East Chicago, Ind.

D. C. McCRADY, Superintendent Electrical Dept., Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada

C. ALLAN SCHURR, Control System Engineer, The Electric Controller and Manufacturing Co., Div. of Square D Co., Cleveland, Ohio

A. W. SCHLECHTE, Chief Electrical Engineer, Granite City Steel Co., Granite City, Ill.

EARL A. NEEB, Plant Manager, Titanium Metals Corp. of America, Toronto, Ohio

LEONARD HAM, Superintendent Hot Strip Mill, Granite City Steel Co., Granite City, Ill.

C. C. Thomas: While it is true a completely automatic mill may be some years in the future, partially automatic mills such as described in this paper are becoming more common. The trend toward more automatic features has greatly accelerated since the term "Automation" became popular at management levels.

Presetting the screw positions and relative speeds is a logical first step in automating a reversing hot mill, however in the past it has been our experience that much of this equipment will remain idle and unused unless a simple method is provided for quickly and simply setting up new schedules. The more often schedules are changed, the more necessary such a feature. Our company built and shipped this spring a system, soon to be installed, which will preset a complete rolling schedule by the insertion of a prepunched card. It is to be expected that this principle will become more and more popular—not only for presetting screws and speeds but for other functions associated with the mill.

I noticed that on this particular mill the relative speed between the edger and main mill was preset in 10 per cent increments. I am somewhat curious as to why such coarse steps were taken, since there are people in the industry who feel that a much closer speed relationship would be desirable in order to minimize the horsepower transmitted through the material being rolled, particularly on the later passes where it can affect the width.

Also it is my feeling that in general the trend on preset screwdowns will be toward the use of adjustable voltage systems on future equipments because of their greater flexibility and accuracy in positioning, the ability to obtain wider stable speed ranges, and reduced contact and brake maintenance.

I also noticed in this paper several references to the use of stepping switches and wondered if the author would comment on their durability and reliability, since I have felt a general reluctance in the steel industry to the use of such devices.

B. R. King: Mr. Schurr described very closely the screwdown control we have on our wide flange beam mill which was installed in August, 1955, except we do not have the dual schedule panel. We have had virtually trouble free experience with it to date and it is doing very nicely.

I would like to inquire if you use constant potential or adjustable potential power on the screwdown. We use the ward leonard adjustable potential power.

Another thing that I would like to inquire about is the compound-wound motors driving the screws. We use the shunt-wound motors for better speed control. Have you had any trouble with speed matching as a result of using compound-wound motors?

D. C. McCrady: Do you use templates in order to set the slide panels for standard rolling sizes, or do you set up each panel individually?

Also, how many slab size changes or product size changes would you run into in an hour's rolling. What I am getting at is, that if there was a wide product range, how long would it take to set up the different schedules considering that you have to set up a screw position for each pass, the edger adjustment, the edger speed, and the number of passes, and whether or not that requires an extra man to do that part of the work. As an alternative, I wondered whether a punch card system for at least the standard schedules might be worthwhile to use so that you could assure optimum rolling conditions as derived from rolling studies of one sort or another. In other words, is there any possibility of using a combination of punch card for standard schedules and a slide board arrangement for special schedules.

C. Allan Schurr: Mr. Thomas questioned the use of only 10 per cent relative speed increments between the edger and the main mill. This was specified by the customer on the basis of some engineering calculations and apparently is adequate as borne out by the performance of the installation. There is no reason, however, that finer increments cannot be supplied as dictated by the requirements of any particular installation. In one case, we have supplied twenty draft compensation positions.

Although the Granite City installation is constant potential, we also have several adjustable voltage installations in operation, the Inland Steel controller mentioned by Mr. King being a case in point. We are presently engineering both types. In our laboratory, we have set up a complete screwdown controller system which is equipped to operate either as a constant potential or an adjustable voltage drive so that we can compare performance for various types of installations.

When we first introduced our preset screw-down controller some twenty-five years ago, we did experience a bit of trouble with the stepping relays. These relays had several adjustments on them. I think that some of the trouble was due to the customers' re-adjustments in attempt to improve their performance. In the last four or five years, we have gone to a new type of stepping relay which has been virtually trouble-free. There is only one adjustment on it and it is factory set and seems to need no further attention.

When card readers are used for programming these controllers, there is no stepping relay since the card itself indexes ahead under control of a small motor in the card reader so that the card reader actually incorporates the function of a stepping relay.

Mr. King has asked about the use of compound-wound motors on these installations. Most of the controllers for constant potential systems have used compound-wound motors. There has been no difficulty in load sharing as a consequence of the inherent motor droop. Regarding accuracy of positioning, we except positional tolerances of about $\pm\frac{1}{4}$ of a vernier increment. A good part of this error is due to deflection in the mill itself.

A. W. Schlechte: A question was asked about speed matching. At the time that was being discussed it was apparently considered that 10 per cent steps were sufficient and that was the only reason that was done.

About trouble on stepping relays, we did have a little trouble at one time and we really caused the trouble. We connected a relay in parallel with the pass indicating light, and the relay took a little more current than the contacts could handle, so finally one of the contacts burned a little bit.

Regarding use of the template, we do not. It was considered at first and provision was made with a couple of clips at the bottom so that a template could be put in, but we have not found it necessary.

We roll slabs at the rate of 60 an hour and oftentimes we change the schedule on each slab. I do not mean 60 are changed an hour, but we will roll a slab, change a schedule and roll another slab and change the schedule, and there is no time lost in the change of the schedule.

We have two men in the pulpit, the operator and a relief operator. One man sets up the schedule as needed and the other man operates the push button that controls the mill.

Earl A. Neeb: I would like to ask several questions. I am more concerned with operating procedures rather than the electrical method of making it work.

In having automatic control of the vertical and horizontal mills, what type of schedule do you use for the vertical mill? Are you coming in or going out as you reduce the slab in thickness?

How good is your control over the width of the slabs that are delivered to the mill?

Is it only being used on carbon steel?

Leonard Ham: On the edging passes, we usually set up our third pass at $\frac{3}{8}$ in. under the desired width as it comes out of the finishing mill. On our last pass, we set up at the exact desired width and we find that the spread compensates for the difference.

On the control of the width coming into the mill, we have fairly good width control coming into our mill. I would say that our slabs do not vary over $\frac{3}{8}$ in. from the ordered width, and we order our slabs a half in. less than the finished width off the mill.

Practically all of our steel is mild steel.

. . . . maintenance cost should be recognized as an actual product cost and receive the same engineering and planning as process and product engineering . . . .

PRODUCTIVE MAINTENANCE

By
R. G. RETTIG
Manager, Service Shops
General Electric Co.,
St. Louis, Mo.

▲ OUR company has come to look upon maintenance as a basic consideration in product design. We are making every effort to design electrical equipment with an eye to easy maintenance, and easy installation—a far cry from the engineering practice of twenty years ago. It cannot be said too often; maintenance and production in our modern highly-mechanized industries are almost blood relations, and one of our most important manufacturing jobs is to make maintenance as convenient and as simple for you as we possibly can.

When comparing the equipment investment costs to material and labor cost increases, the cost of unplanned shutdowns increases. In the iron and steel industry, the capital investment is enormous compared to labor and material costs. The lessons steel men have learned can be extremely useful to maintenance men in other industries.

When the drive for one set of rollers in a steel mill fails, a lot more than that drive is knocked out. If it is a part of a hot mill, the whole hot mill is shut down until the drive is repaired. This means lost time, lost production, upset schedules and the host of evils that follow in the wake of unplanned shutdowns. Recently, the failure of a single motor caused an entire strip mill to shut down. Orders were urgent but ten days were needed for repair.

Routine maintenance must eventually reach a point of diminishing returns. Inspection, cleaning, oiling and all other tasks that are a part of maintaining equipment cannot make a new motor out of an old one. Insulation may last a long time, but it is perishable. Heat accelerates its aging and steel mills, you'll remember, are hot.

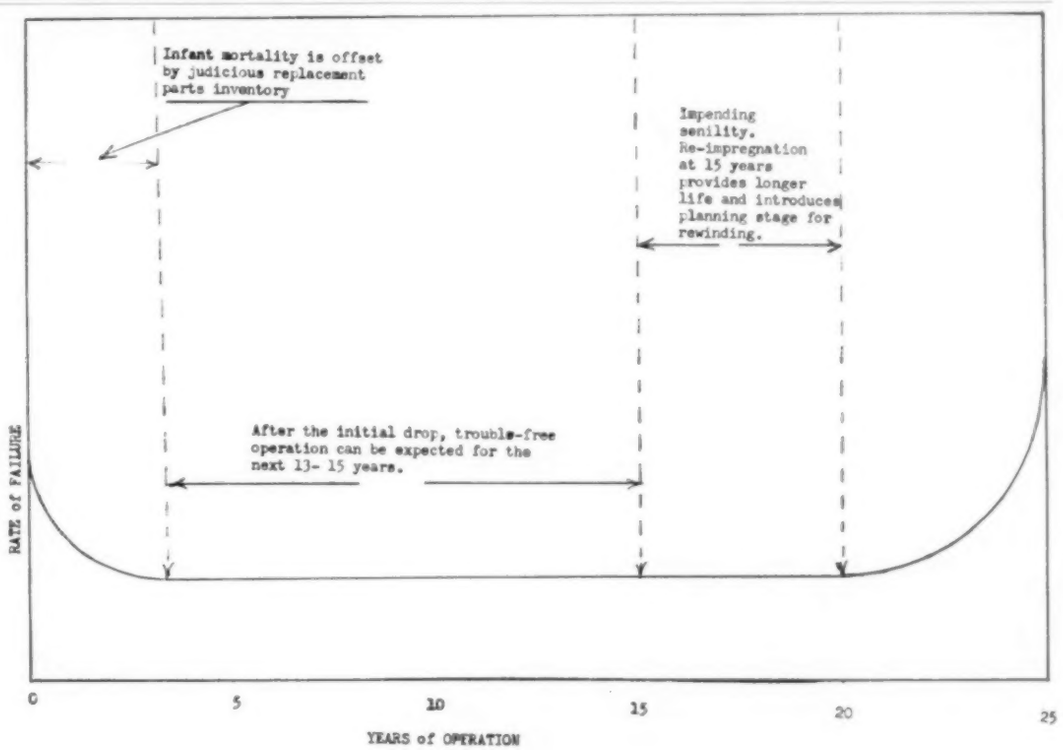

Infant mortality is offset by judicious replacement parts inventory
Impending senility. Re-impregnation at 15 years provides longer life and introduces planning stage for rewinding.
After the initial drop, trouble-free operation can be expected for the next 13- 15 years.
RATE of FAILURE
0
5
10
15
20
25
YEARS of OPERATION

Figure 1 — Trouble can be predicted from life expectancy curves.

Figure 2 — Damage may occur in the core laminations when rotor windings go to ground in the slot portion of the rotor core.

Steel mill electrical maintenance is therefore a science based on life expectancy curves of motors. Motors, like people, follow a certain pattern which can be charted.

Our maintenance program is based on an expectancy which itself is based on experience. See Figure 1.

A high rate of failure is usually encountered in the first two years of operation. These failures arise from three main causes: poor workmanship, incorrect design, and wrong application. This first stage can be called infant mortality; and has the same correlation to motors as it has to humans.

To guard against protracted shutdowns in the first period, smart maintenance men carry an inventory of spare coils. Motors can be repaired quickly and put back into service if parts are available.

In building a parts inventory, take into account results of failure of the motors being backed up. Protect the most essential ones first.

Motors that are vital to the plant operation should be more carefully protected than those which serve an isolated function that can easily be taken over by other machines.

The second period of motor operation, between two to fifteen years, represents middle age. Those machines that have survived the childhood diseases now give relatively trouble free service. The only ailments to which the survivors are subject are the failures which experience has shown to be inevitable in plant operation.

During this middle-age period, inspection, oiling, cleaning, brush replacements, etc., are the prime concern of the maintenance department. Routines should be organized so each essential piece of equipment gets the attention commensurate with its need and its importance to the operation of the mill.

During this period, the spare parts purchased originally with the new motors are insurance against prolonged shutdowns.

With coils packed for long time storage, the shelf aging effect of air is thus practically eliminated.

After fifteen years, the rate of failure begins to rise. Insulation has begun to dry. There is a certain amount of play between the windings. Age and vibration have taken their toll.

Old insulation which is subject to mechanical failure is the cause of at least 90 per cent of motor failures. After fifteen years of use, the internal solidity of the

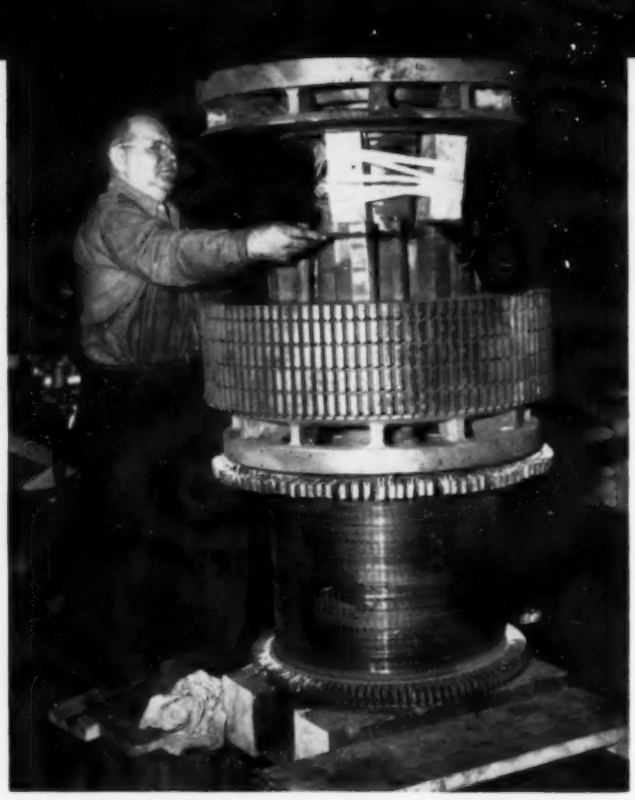


Figure 3 — Laminations are being removed from defective rotor.

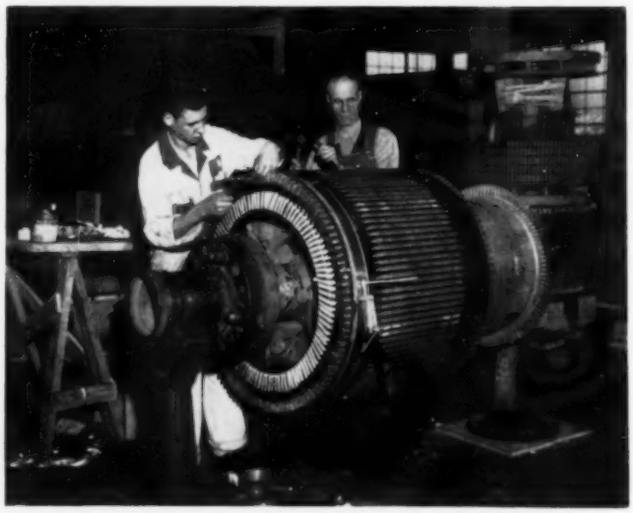


Figure 4 — This armature was found to be ready to fail when inspected at the time of failure of the other armature and was therefore rewound.

motor just is not what it used to be. When two conductors rub against each other—and they can, now that the insulation is dry—that dry insulation will begin to flake off and eventually the conductors will short out.

What can be done about this? Several things, and this is the period we consider the most crucial one in iron and steel industry maintenance.

After fifteen years, electric motors are at a point of impending senility, and a glance at the history of steel production will suggest how much equipment falls in this category. Some action must be taken to continue operation without sitting on a powder keg.

"We have a motor that has been running for twenty-five years with no trouble," one may say. True. Maybe your father lived to be ninety-five, but an insurance company will still set your premium on the basis of average mortality. A productive maintenance program is set up the same way.

At the end of the fifteen-year period of relatively

trouble free operation, continued successful operation can be obtained for another stretch of time. Impregnation with varnish will hold the coils firmly and reduce the possibility of chafing. The blotter action of the dried insulation dramatizes the need for treatment. You can actually see the level of varnish in the vat fall as it is absorbed by the insulation.

This treatment should not be looked on as a permanent repair. Only the outsides of the coils are impregnated; the inner portion is still loose. About five more years of satisfactory operation can be expected. After five years, further steps will have to be taken. During these five years replacement coils should be purchased and inventories of spare parts should be built up. Overhaul schedules should be set up. This means obtaining the most essential parts first with the further precaution that equipment which is in the worst shape be protected first.

Then, as becomes practical, units of the plant are shut down on schedule for rewinding. Because replacement parts are on hand and the shutdowns have been scheduled to conform with production schedules, interference with output is kept to a minimum.

Obviously, such a program requires a fundamental readjustment of our maintenance thinking. Maintenance must be placed side by side with production, and it is up to the maintenance man to realize the importance of this factor—then convince management of it.

The man who quakes at the thought of requesting new testing equipment is not the man who will request a large appropriation for complete overhaul. But if he shows management that it can cost them a half million dollars to do otherwise, he will be doing his job right.

Our company has experienced maintenance specialists who can appraise and analyze critical equipment and, through planning machine overhauls well in advance guard against costly production stoppages.

The electrical and physical condition of the motors and generators in plants should be checked and one should not wait for a breakdown before the specialist is called.

We have forms that are recommended for the evaluation of critical equipment. After a list of critical machines and equipment is prepared, we are ready to assist in filling out these charges and in determining the condition of this critical equipment.

In the preparation of your long-range overhaul schedule, shop facilities may be reserved in advance. When outages are planned well in advance, the service shop can have on hand, ready, the necessary men, tools and materials to do the job fast. This will help keep outage time to a minimum.

These are normal precautions, of course, but machinery does not always act or react according to any norm. For the sudden failure, service shop facilities are available twenty-four hours per day, if necessary.

The purpose of productive maintenance is to awaken industry to the big job ahead all during the next few years, and to remind management that maintenance and down time have a tremendous effect on unit cost. All this means that when management gets a true picture of maintenance costs and recognizes it as added product cost, maintenance will receive the same engineering and planning as process and product engineering. Then and only then, will engineered maintenance be on a productive basis.

By L. SHAW, Service Engineer, General Electric Co., St. Louis, Mo.

Direct-Current High Potential Insulation Testing

. . . . high voltage testing is a satisfactory method of evaluating the condition of motor and generator insulation . . . . this procedure is helpful to the steel plant maintenance engineer . . . .

▲ FOR many years insulation testing with a megger has been accepted practice for maintenance people. In recent years the availability of fairly small, compact high-voltage rectifiers for converting 110-volt, 60-cycle, to as high as 75-kv, d-c has led to the investigation of the condition of insulation on the windings of rotating machines by applying high voltage direct current to the windings and measuring the leakage current to ground.

Before going into the methods used in this type of testing, and the analysis of some of the results, let us look at two fundamental relations between current, voltage, resistance and capacity.

The first of these relations has to do with resistance and was first stated by one George Simon Ohm in 1827 and can be expressed by $R = V/I$.

The second has to do with capacitance and can be traced back to Charles A. Coulomb and can be expressed by $C = Q/V$.

We will not go into the units used for these measurements as all we wish to point out is that a linear relationship exists. These two laws are quite simple when we

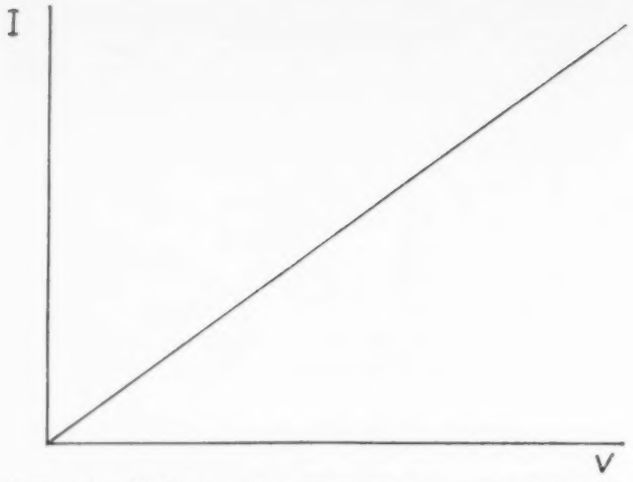


Figure 1 — With constant resistance, current is proportional to voltage.

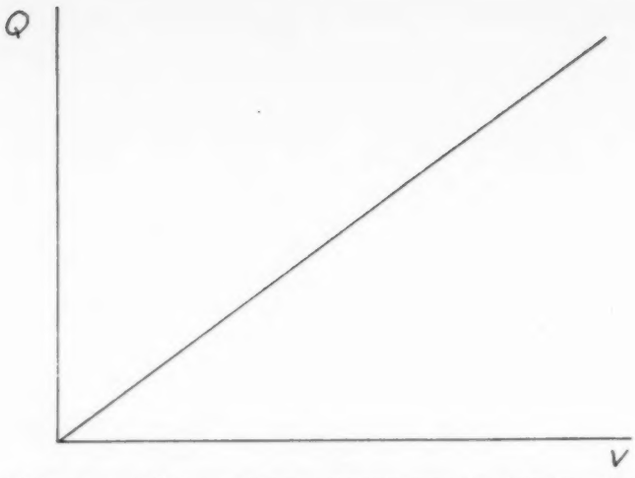


Figure 2 — With constant capacitance in farads, the charge in coulombs is proportional to the voltage.

assume that they have linear relationships over the range of values we choose to use.

If resistance R is assumed a constant value, the relation V/I can be plotted as a straight line curve (Figure 1).

If capacity C is assumed a constant value, the relation Q/V is a straight line curve and can be plotted as shown in Figure 2.

These assumptions of linear relationships do not hold if we want to be extremely precise; however, for most practical purposes they can be assumed to be linear.

The windings of an a-c motor consist of turns of copper wire insulated by various types of insulating material between the turns and from the steel lamination which holds the copper wire or bars in their proper position.

This can be illustrated by a greatly simplified diagram. (Figure 3).

The problem here is to arrive at a method of determining the condition of the insulation between the two materials, copper and steel.

The method under discussion is the application of a d-c voltage across the insulation and measuring the d-c current as the voltage is varied.

In a very simplified drawing (Figure 4) consider the following:

In this case is given the effect of capacity due to the copper and steel lamination being separated by a dielectric, and the effect of resistance due to the flow of current through the dielectric.

As the voltage V is varied, from zero upward, and the current A is measured, there are two components of current. The current to charge the condenser and the current leaking through the dielectric.

If C and R are constant over the values of voltage applied, the plot of voltage and current will give us the type of straight line curve shown in Figure 1.

In applying this type of test to a new winding this straight line, or very nearly straight line relationship, has been observed over the voltage ranges required by AIEE standards for high potential testing of new windings.

We are now making use of this test method to investigate the condition of insulation on machines which have been in service for an extended length of time.

For many years now, the accepted a-c overpotential proof test for new windings, both a-c and d-c over 50 volts, has been two times the rated voltage, plus 1000 volts, applied for one minute.

The high potential test for machines which have been in service for any length of time has been a subject over which there has been much controversy. There are many rules for these tests depending on the rated voltage of the machine, the age of the machine, the operating conditions, etc. Many papers have been written on this subject. Eventually, however, you arrive at some value of a-c voltage you wish to apply to a winding to decide whether you can count on the machine for reliable operation.

Before d-c high potential test sets were developed which could be used in the field, we would first apply a megger to the winding, and if the resistance reading to ground was considered good, an a-c high potential test would be applied to the winding. It could usually be assumed that the winding would withstand the test. Most men have observed cases where with a 1000-volt megger, a reading of winding resistance to ground was recorded which was thought to be sufficient, only to have the machine go to ground on an a-c hi-pot test.

The use of direct current to investigate the condition of the windings of a machine has given another approach to this problem.

A d-c voltage is applied to the winding, with the ground side of our test set grounded to the frame of the

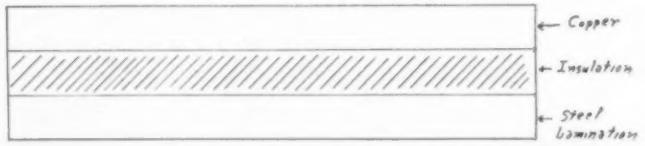
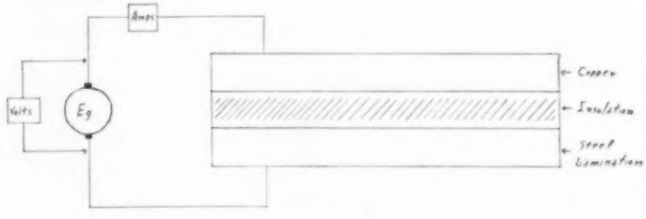


Figure 3 — Simplified sketch shows function of insulation.

Figure 4 — Circuit used in checking condition of insulation.



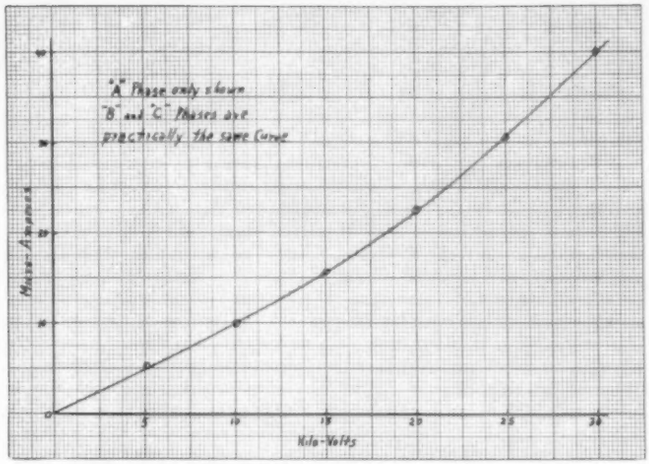


Figure 5 — Test curve on 75,000-kva hydroelectric generator after rewinding.

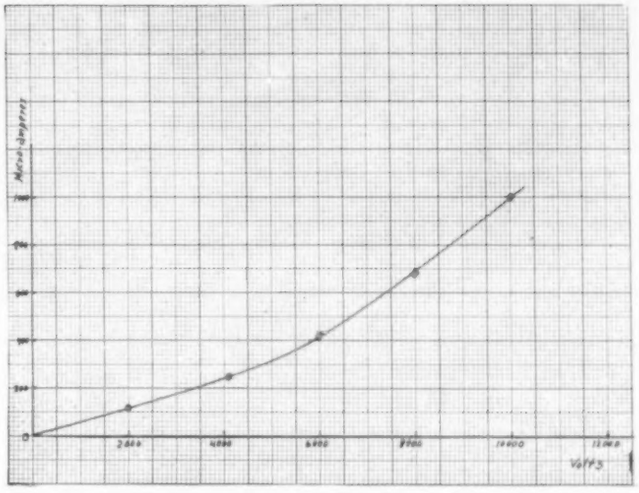


Figure 6 — Test curve on 450-hp, 60-cycle motor after 30 years service.

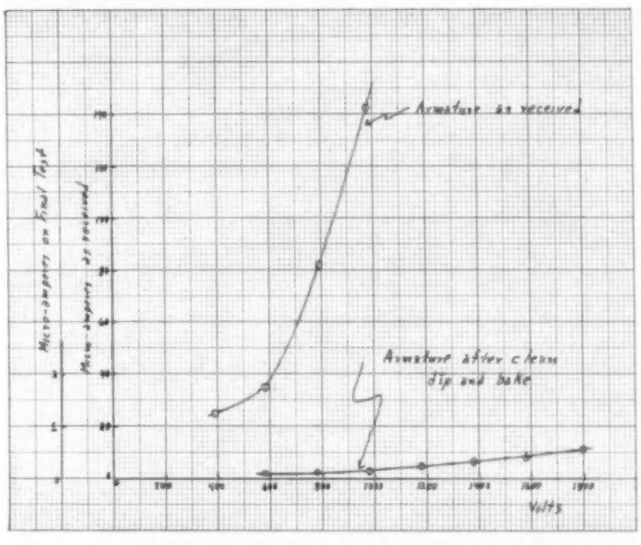


Figure 7 — Test curves show improvement effected by cleaning and baking armature.

machine. The leakage current is measured as this d-c voltage is varied from zero, upward.

The value of voltage versus current are plotted as the test is run. On the horizontal axis of the graph paper is the d-c applied voltage scale. On the vertical axis is laid out the dependent variable, the current, in microamperes. When the maximum d-c voltage to be applied has been decided, the voltage scale is divided into even increments. The first d-c voltage increment is then applied. As the voltage is raised from zero to the first point, the ammeter will show the summation of the charging current and the leakage current. The time it takes for the charging current transient to die down is measured. After the current has become stable, it is recorded as well as the time interval required. The voltage is then raised to the second point and this procedure is repeated. The values of voltage and current are plotted and the curve is drawn as the test is run.

The time interval of taking the reading is quite important. On relatively small motors with good insulation the current will stabilize very quickly.

On large equipment, on the order of a 100,000-kw generator winding, once the total current has apparently stabilized, we proceed to the next point on the test, using even increments of time, even though the charging current may be still decreasing. The time intervals used are part of the techniques of this type of testing which can only be gained by experience.

The interpretation of the curve as it is plotted is extremely important. Here again experience is needed. If the voltage versus current relation remains linear over the range which had been decided before the test was started, the test range can be extended.

If the curve starts sweeping upwards rapidly, or shows signs of becoming unstable, the test should be stopped and an investigation made.

A few examples of test curves on machines are interesting and informative.

The test curve of Figure 5 is from a 75,000-kva, 138.5-rpm, 13.8-kv, 60-cycle hydro-electric generator which had been rewound. The test went to 30-kv, d-c in 5-kv increments. Voltages were held for ten minute readings. From one voltage step to the next voltage step took about one minute.

A similar curve in Figure 6 is for a 450-hp Motor, 4150-volt, 60-cycle, 180-rpm. The stator windings on the machine were 30 years old but had been kept clean, dry and varnish treated.

Data in Figure 7 is for a 300-kw armature and illustrates the quite marked change in resistance to ground which can be effected by good maintenance work.

The question of how much d-c voltage to apply to a winding in relation to the a-c voltage of a comparable a-c hi-pot is one on which there has been considerable discussion.

Assume a pure sine wave as shown in Figure 8.

The following equation holds:

$$E\ (\max) = 1.414\ E\ (\text{rms})$$

E (rms) is the voltage measured by a dynamometer type voltmeter. It would appear then that a d-c voltage of 1.414 times the a-c (rms) voltage would be equivalent. In actual practice, however, a ratio of 1.5 and 1.6 has been determined experimentally as will be shown.

A great many tests have been run on machines, and curves as shown in Figure 9 have been obtained.

The tests were halted when the currents began to curve upward too rapidly, then the curve was projected until it became parallel with the vertical axis. The projection of this curve down to the voltage axis

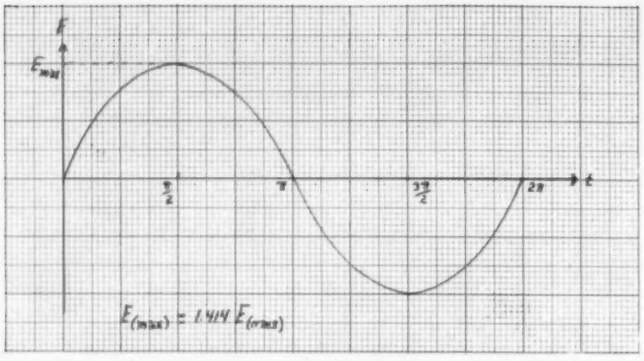


Figure 8 — Variation of voltage through one cycle.

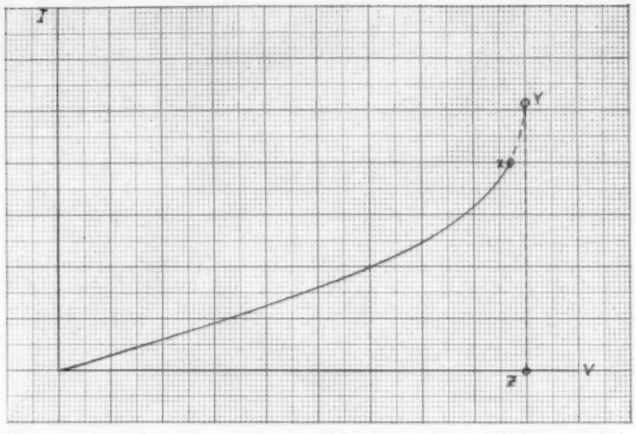


Figure 9 — Curves such as this give the voltage which predicts when the winding should fail.

gives a d-c voltage at which the winding could be expected to fail, if this voltage was actually applied.

Converting this d-c value to a-c by dividing it by 1.6 and applying an a-c voltage to the winding, and raising this a-c voltage to the value determined, has resulted in insulation failures which have on the average verified the 1.5 and 1.6 ratio.

Another of the interesting things revealed by d-c insulation testing is that in many cases, so called, cleaning up a winding has made the resistance reading to ground less than what it was before the cleaning operation.

This can happen easily in the case of an armature where retaining bands over the coils and commutator V rings under the winding, complicate the cleaning process.

There are a number of conclusions which can be drawn from the results of many tests made using high voltage direct current.

One of the obvious conclusions is that these tests will not reveal the conditions of turn-to-turn insulation in a winding. This is quite so. Work needs to be done on developing a practical test method for this problem, which can be done on developing a practical test method for this problem, which can be used in the field. One can assume, however, that measurements of the condition of the insulation to ground is also an indication of the condition of the turn to turn insulation.

Some people, however, say that no conclusive answers can be drawn from this type of test.

Other people say that d-c insulation testing is "*the*" method for determining the true condition of insulation in a machine.

If we adopt an approach between these two extremes, and put this type of testing to use, a great deal of knowledge will be gained which will be of help to the steel industry in solving its maintenance problems.

The Pacific Gas and Electric Co., one of the world's largest utilities has been using this method of testing for quite a few years. The Detroit Edison Co. also has described very extensive use of these tests. The conclusion arrived at by Detroit Edison is that d-c high-voltage testing is a satisfactory method of evaluating the condition of generator insulation.

It remains for the people in the steel industry to investigate this new concept and put it to use as an aid to steel production.

AISE ANNUAL CONVENTION

GOLDEN 50 YEARS ANNIVERSARY

September, 23, 24, 25, 26, 1957

Penn-Sheraton Hotel

Pittsburgh, Pa.

Basic Data on Mechanical Cleaning Operations in steel plants

By GILBERT D. DILL
Engineer in Charge of Steel Div.
Wheelabrator Corp.
Mishawaka, Ind.

....eight major applications of wheel blasting are now in operation in various steel plants ....results are increased production, reduced costs and improved product....

▲ ON October 1, 1954 our first report covering the progress of our mechanical cleaning process over a ten year period was given at the Annual Convention of the AISE. (See 1955 Proceedings AISE). This paper will be a factual report on additional progress and the operation of key installations.

The art of mechanical cleaning or descaling is today a far cry from the old operation of compressed air sandblasting. It is now an efficient, low cost operation and is being used by nearly all major steel mills and by a large number of manufacturers who process steel in all of its various forms.

To achieve this goal of acceptance by the steel industry, we have through design, research, and development attained and can offer (1) low cost per ton of material cleaned, (2) a clean surface, and (3) high continuous production with minimum downtime.

Nearly 100 operating installations on all of the major applications of our process indicates that we have been successful.

This progress has been helped to a considerable extent by the development of an abrasive which would last so long that abrasive cost was minimized and which at the same time did not have a severe effect on wearing parts.

Today our $2,500,000 abrasive plant is producing high carbon, high manganese, fully heat-treated *cast steel shot and grit* backed by a quality warranty. Its present production capacity is in excess of five times the current abrasive requirements of the steel industry.

This new abrasive (Figures 1 and 2) has a controlled hardness factor for faster cleaning. It has toughness and solidity for longer life. Because of its roundness and resistance to breakdown, it drastically reduces wear and maintenance costs and practically eliminates surface contamination through imbedment of sharp par-

Figure 1 — Chilled iron shot shows relative breakdown after 1500 passes through a centrifugal blasting wheel, at 7.5 magnification.

Figure 2 — Cast steel shot shows relative breakdown after 1500 passes through a centrifugal blasting wheel, at 7.5 magnification.

ticles of abrasive broken off upon impact. Finally, the quality insures uniformity and lowest overall cleaning costs.

It is interesting to compare the performance of this new abrasive with the old cast iron abrasive originally responsible for the above mentioned objections. One of the large installations consumes seven pounds of cast steel shot per wheel per blasting hour as compared to 50 pounds of cast iron shot in our earlier machines. At present abrasive prices, this amounts to 93 cents per hour for cast steel shot and $3.00 per hour for cast iron shot or a reduction of 69 per cent in abrasive cost.

Further reduction in costs has resulted from the development of fully heat-treated chrome-moly cast steel wear-resisting parts and new high carbon, high chrome wheel blades recommended for all steel mill installations.

Formerly these parts, excepting the wheel blades, were made of mild steel with a maximum life expectancy of two weeks. The new abrasive resisting parts have a proven life of 50 times that of mild steel (Figure 3). In fact, some users report a life ratio of as much as 150 times that obtained with mild steel.

Cost comparison of this material with mild steel shows that a premium quality wear plate selling for $30.00 would have to be replaced after 100 weeks of service while a mild steel plate of the same size and in the same service and selling for $7.20 would have to be replaced 50 times in 100 weeks of service at a cost of $360.00. This amounts to a reduction in parts cost of 91.75 per cent. Obvious savings are obtained through reduction in maintenance labor and downtime.

The premium quality blades are the result of many years of research in our metallurgical laboratory. They are manufactured under special processing technique to achieve their resistance to severe abrasive wear and breakage.

Their service life is consistently over 1000 hours of blasting time in steel mill applications. They have made it possible to set up a routine program in which each wheel of a multiple wheel machine may be refitted once every six to eight weeks. The increased efficiency of our wheel units and the reduction in downtime are obvious. Some sets of blades have given over two years of service before replacement.

The efficiency of machine operation has been further increased through the development of an entirely new super-capacity wheel unit. It is the most powerful and efficient centrifugal blasting wheel ever built (Figure 4). Depending on the size of wheel and its motor drive it will throw up to 2000 lb of abrasive per min. Its tremendous blast is uniformly spread over the work resulting in faster and cheaper cleaning. All details of this new wheel have been designed to take care of the powerful abrasive flow and to reduce maintenance time and costs to a level never before possible.

Thus from the above we can state with assurance that the steel industry's major objections to the mechanical cleaning process have been overcome.

Basically the function of a wheel blast cleaning machine is to efficiently and cheaply remove scale from hot mill products. This simple requirement is, however, but a part of the complex problems of applying the process. We must, in addition provide for the following important factors:

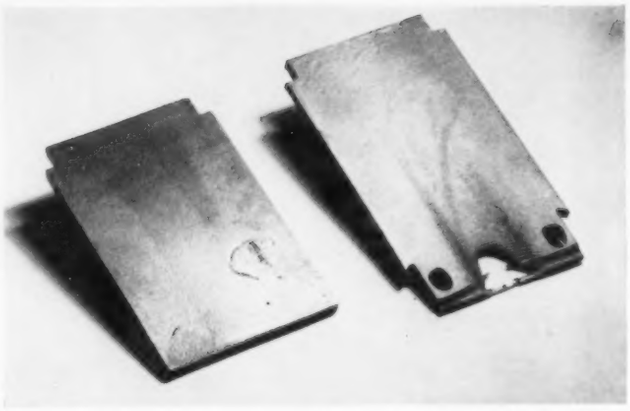


Figure 3 — Premium quality liner plate (on left) after 7500 operating hours in a mechanical cleaning cabinet is compared with a mild steel liner completely worn out in only 48 operating hours in the same cabinet.

1. Type of product to be cleaned.
2. Size and shape of product.
3. Production in tons per unit of time.
4. Surface finish after cleaning and its effect on:
   a. Cold rolling.
   b. Cold forming.
   c. Cold drawing.
   d. Fabrication.
   e. Coating.
   f. Final end product.

The methods used to efficiently handle these factors in practice have been thoroughly developed through laboratory tests and operating installations.

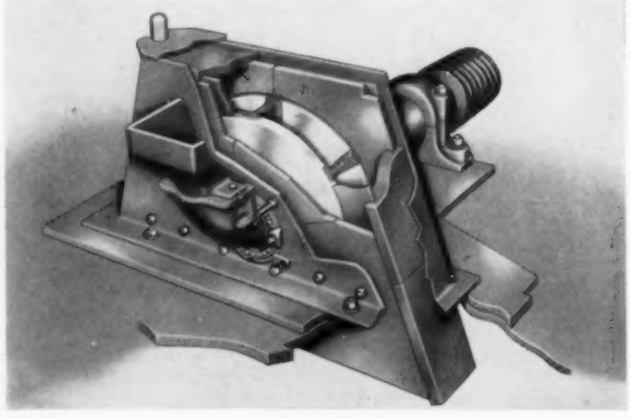
It is not necessary to give in this paper lengthy descriptions of key installations. Most operators are familiar with the process and equipment, and have had it in operation in their plants on one or more applications.

The facts and figures given in the ensuing paragraphs are as complete and accurate as can be compiled from the available records.

DESCALING SLABS AND BILLETS FOR INSPECTION

There are several installations operating on this application but the largest and newest is in the plant of a large producer of alloy steel in Canada, consisting of a feed conveyor loaded by overhead crane, the mechanical cleaner, and a runout conveyor with drag unloader for storing slabs on skids.

Figure 4 — Life of centrifugal blasting wheels has been improved.



Their blast unit is a four-unit 19½ × 5-in. wide wheel machine. The wheels are so arranged that complete blast coverage can be achieved on billets up to 15 × 15 in. and slabs up to 24 × 6 in. The abrasive used is cast steel shot.

At present they are operating one 8-hour turn with one operator and producing about 75 tons per turn of continuous cast slabs 10½ × 2¼ in. × 30 ft-0 in. long in the 300 and 400 series stainless alloys at cleaning rates varying between 3 and 14 fpm.

The 75 tons per shift represent part-time operation. A capacity of approximately 325 tons is indicated with a total operating cost per ton of 95¢ per ton or less depending upon the abrasive.

The completely descaled slabs from this line are given a close inspection and defects are removed by spot grinding. We are informed that it is most important to remove all defects in this operation as these slabs are hot reduced on a new type planetary mill.

In connection with this application of our process, we have recently developed a new method of descaling for inspection. It is particularly effective where fine seams and checks must be disclosed. To achieve this, we use for abrasive a cast steel grit having a controlled hardness factor, and blast the slab or billet at right angles to the direction of rolling. In addition, we control the amount of scale removed so that all defects retain scale below the normal surface thus disclosing the defect's location due to its scaled outline against a nearly scale-free surface.

CONTINUOUS STRIP CLEANING

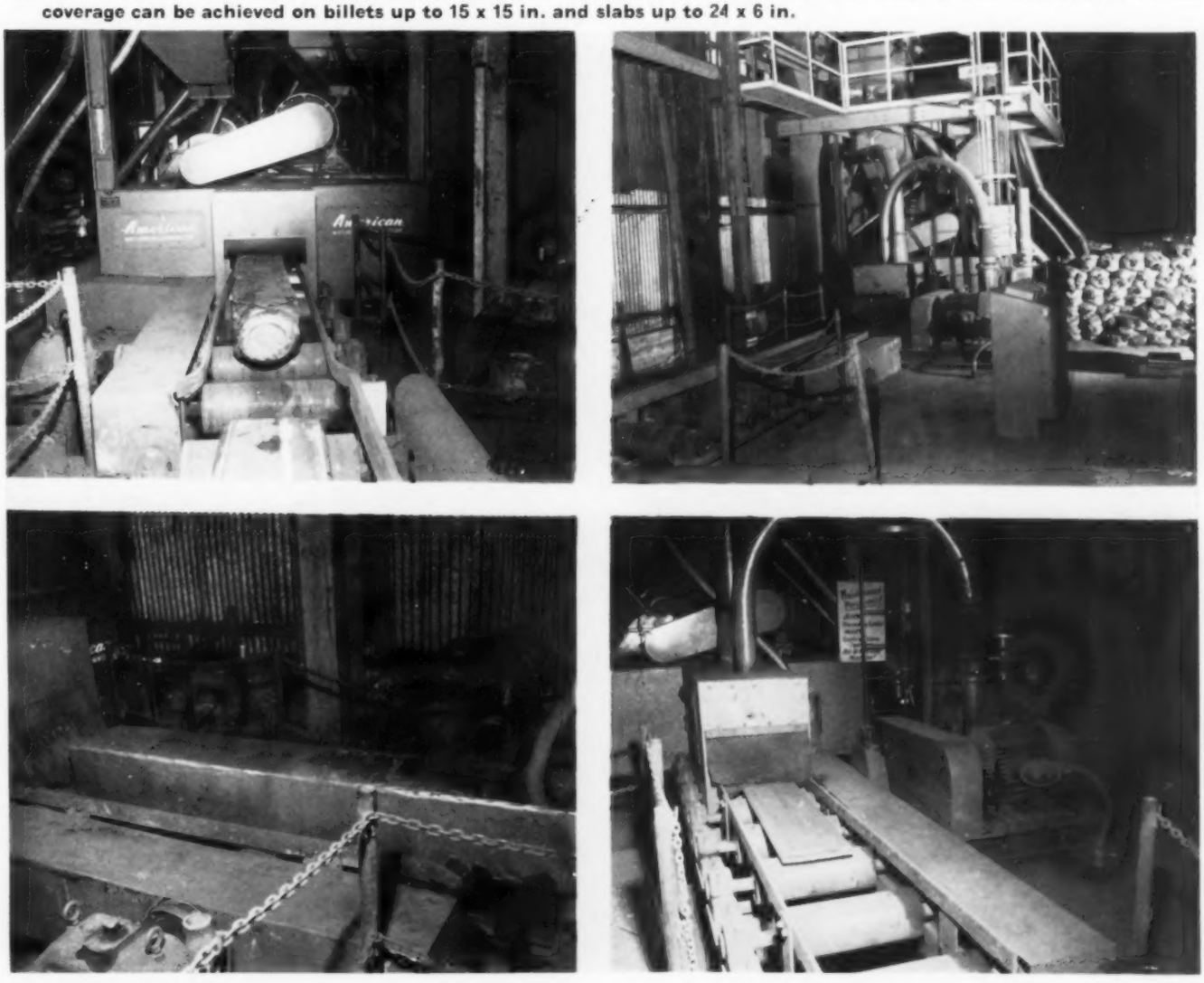
Most operators are familiar with efforts to replace acid pickling with mechanical cleaning. This goal has been achieved on material used in all types of finishing processes except reduction in gage by cold rolling.

Where this operation follows, the mechanical cleaning process, we require a 12 to 14-sec flash pickle to remove a thin layer of tough amorphous iron which exists on carbon steel coiled at the hot mill at temperatures above approximately 1150 F.

It was through steel plant metallurgists that we discovered the existence of this material and its creation of a black graphitic smut on the surface of carbon steel material during cold rolling. In connection with this problem I would like at this time to correct an erroneous belief that seems to prevail throughout the industry. It is stated that mechanically cleaned material has a dirty black smut on its surface which precludes the use of this process as compared to an acid pickled material.

It is true that a blasted material retains a minute

Figure 5 — Cabinet, with four blasting wheels, is used for descaling slabs. The wheels are arranged so that complete blast coverage can be achieved on billets up to 15 x 15 in. and slabs up to 24 x 6 in.



amount of scale dust as a result of the pulverizing effect of the blast. However, if material is processed at the rate required to remove all adhering scale, this dust condition will not affect subsequent processing. If all scale is not removed, the effect on additional processing will be the same as you would get with underpickled material.

As proof of this statement, we have operating installations cleaning material for deep drawing, electrolytic plating, hot dip galvanizing and other uses where scale in any quantity will cause rejection of the finished article. No acid pickle is used. The material is processed as it comes out of the blast cleaner.

Our key installation on strip cleaning is in a recently modernized mill in Ohio. It is a large sixteen wheel unit with wheels 19½ × 5-in. wide with hydraulically adjustable wheels to efficiently apply the abrasive blast to cover 24 to 42 in. wide × 0.09-in. to 0.189-in. gage carbon steel strip. (See Figure 6.) It is installed in a modern high speed conventional pickle line, comprised of standard components except that it replaces all of the acid but that contained in one 60-ft tank.

It has operated 3844 blasting hours as of August 25, 1956 and is cleaning satisfactorily for cold rolling at a rate of 250 fpm maximum.

The following production and cost figures are taken from the records for the month of May 1956.

Production

1. Tons per month = 19,500.
2. Hours of operation = 408¼.
3. Tons per hour = 48.
4. Average gauge = 0.109 in.
5. Average width = 34½ in.
6. Cast steel shot per ton = 2.4 lb.
7. Acid per ton = 14 lb.
8. Coating oil per ton = 2.34 lb.

Operating cost per ton for above production

1.	Operating labor	= $0.39
2.	Indirect labor	= 0.11
3.	Repairs and maintenance	= 0.68
4.	Welding supplies and gas	= 0.04
5.	Cast steel shot	= 0.30
6.	Acid—66° B.	= 0.17
7.	Coating oil	= 0.26
8.	Miscellaneous supplies	= 0.01
9.	Steam	= 0.19
10.	Electric current	= 0.23
11.	Water	= 0.01
	Total direct cost	$2.39 per ton

In this installation about 75 per cent of acid requirements have been eliminated.

In addition to this key installation, we have in operation in the steel mills over 20 units cleaning in conjunction with acid pickling stainless steel, high silicon, high carbon, titanium and other alloy material. There are also several units cleaning carbon steel without acid pickling for products which are deep drawn and electrolytically plated or hot dip galvanized.

Our key installation on hot rolled alloy strip in the Pittsburgh district (Figure 7) is a six 19½ × 5-in. wide wheel unit with the wheels so arranged that complete coverage by the blast is maintained on material 33 to 50 in. wide by 0.080 to 0.250 in. gage.

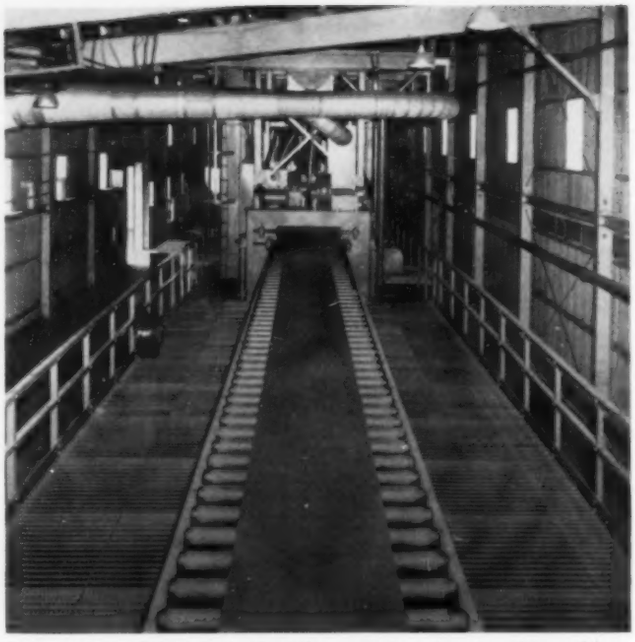


Figure 6 — Carbon steel strip, varying in size from 24 to 42 in. in width x 0.09 to 0.189 in. is cleaned satisfactorily for cold rolling at the rate of 250 fpm in this 16-wheel cabinet.

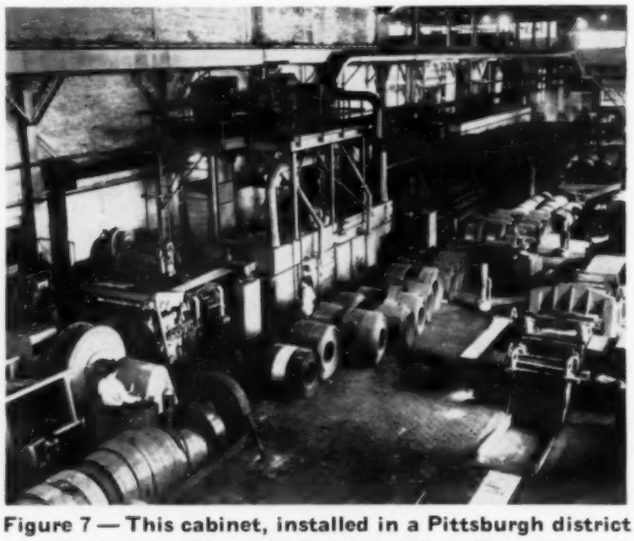


Figure 7 — This cabinet, installed in a Pittsburgh district plant, is used for descaling hot rolled alloy strip.

Figure 8 — This cabinet is used for descaling carbon steel prior to drawing and then galvanizing for such products as switch boxes, outlet boxes and covers, etc.

The machine uses cast steel shot for scale removal and is followed by three 60-ft. acid tanks. When cleaning silicon steel, all three tanks are charged with 15 to 20 per cent sulphuric acid at 180 to 200 F. When cleaning chrome strip two tanks remain on sulphuric acid and the third tank is charged with 10 to 12 per cent nitric acid and 1 to 2 per cent hydrofluoric acid at 150 F.

This line operates at an average speed of 200 fpm on silicon with a top speed of 250 fpm. It produces an average of 20 tons per hour at a total cleaning cost of $6.50 to $7.00 per ton on chrome strip and $5.00 to $5.25 for silicon.

On chrome steel this line operates at 60 to 70 fpm with complete elimination of the expensive cold mill scalebreaking operation. The speed of 200 fpm on silicon compares to a line speed without mechanical descaling of 50 to 60 fpm. Thus, the blast cleaning process increases the chrome production 100 per cent and the silicon production 400 per cent.

Another key installation in the Pittsburgh district is a complete mechanical line (Figure 8) without pickling, cleaning carbon steel in widths up to 48 by 0.060 in. to 0.187 in. gage. The cleaned material is slit, stamped and cold drawn into electrical products such as switch boxes, outlet boxes and covers, junction boxes, etc. The parts are then electrogalvanized in an automatic processing line.

This line is equipped with a four 19½ × 5-in. wide wheel and cleans at a rate of 30 to 40 fpm. Its production averages 50 tons per 8-hour day, and by adding an occasional shift, they average about 1400 tons per month.

The entire cost per ton for the line is $3.00. The blaster uses 3.12 lb. of cast steel shot per ton at a cost of 38¢ and their power charge is 23¢ per ton. This leaves a balance of $2.39 to cover direct and indirect labor, maintenance parts and overhead.

It is interesting from a maintenance standpoint to note that this machine, completely equipped with wear resisting alloy protection, has operated 1257 blasting hours with no replacement of wheel blades or liners. Photographs of these parts indicate a life of at least 3000 hours.

SHEET AND PLATE CLEANING

There are more than 24 installations cleaning cut lengths of material in nearly all widths and gages and at speeds ranging from 10 to 240 fpm.

Our key installation is a simple mechanical cleaning line composed of an automatic all-electric feeder, cleaner and stacker. Because of this simplicity, we have been able to secure the following excellent production and cost figures.

The blaster is a four-unit 19½ × 5-in. wide adjustable wheel machine (Figure 9) equipped with a pinch roll type conveyor with variable speed drive. It uses about 7½ lb per wheel per blasting hour of cast steel shot and cleans sheets ranging in width from 33 to 65 in. by 0.078 to 0.250 in. gage by 34 to 62 in. long. The degree of cleaning must be nearly 100 per cent to prevent die wear and is performed at rates from 30 fpm on the wide stock to 60 fpm on the narrow stock. This degree and rate of cleaning gives them an average production of 10 tons per hour.

The operating cost of this entire line is $1.43 per ton, broken down as follows:

Abrasive	=	$0.35
Parts	=	0.12
Labor (direct and indirect)	=	0.60
Building depreciation	=	0.01
Equipment depreciation	=	0.35
Total cost per ton		$1.43

None of these installations is followed by flash pickling. The previously mentioned scale dust is present in greater or lesser degree depending on the customer's specification as to "how clean is clean" or what percentage of scale can be left on the steel without affecting their end product. As an example, one of our customers has actually counted the particles of scale remaining on the steel after cleaning. He reports 32 particles, 0.002 in. diam. per sq. in. and for their product, which is automobile frames, this small amount of minute scale when mixed with drawing oil assists rather than hinders their cold forming operations. On the other hand, we have other customers who are

Figure 9 — Four wheel cabinet cleans steel sheets ranging in width from 33 to 65 in. by 0.078 to 0.250 in. gage by 34 to 62 in. long in an Illinois plant.

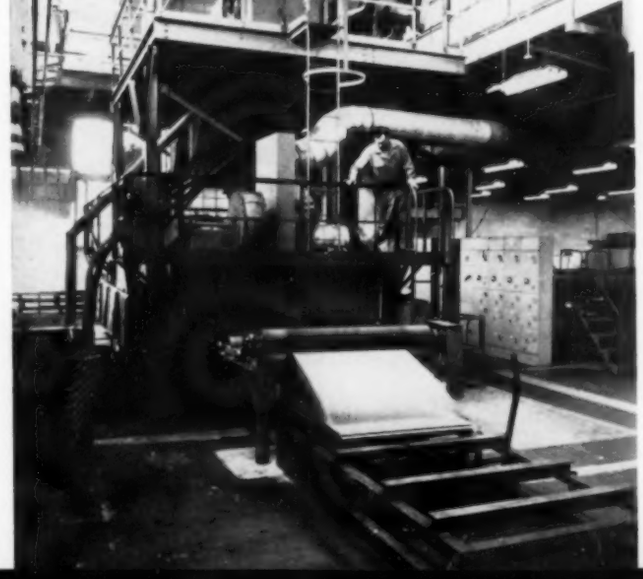
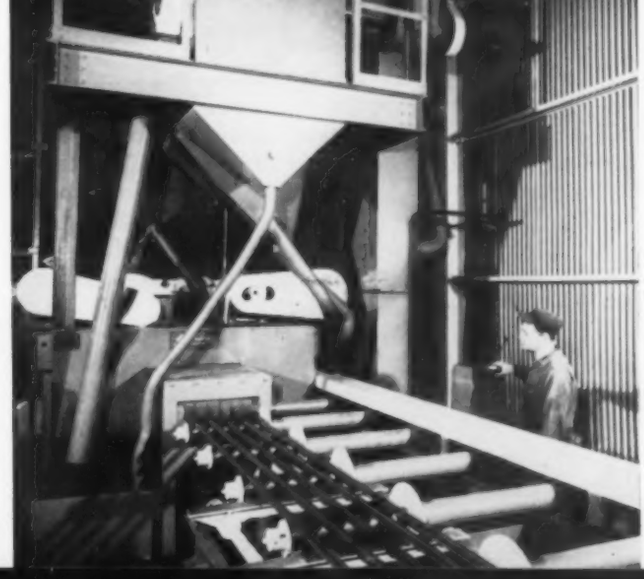


Figure 10 — Extruded shapes in bar form are cleaned in a cabinet in a large steel mill in the Pittsburgh district. Five bars are cleaned simultaneously.



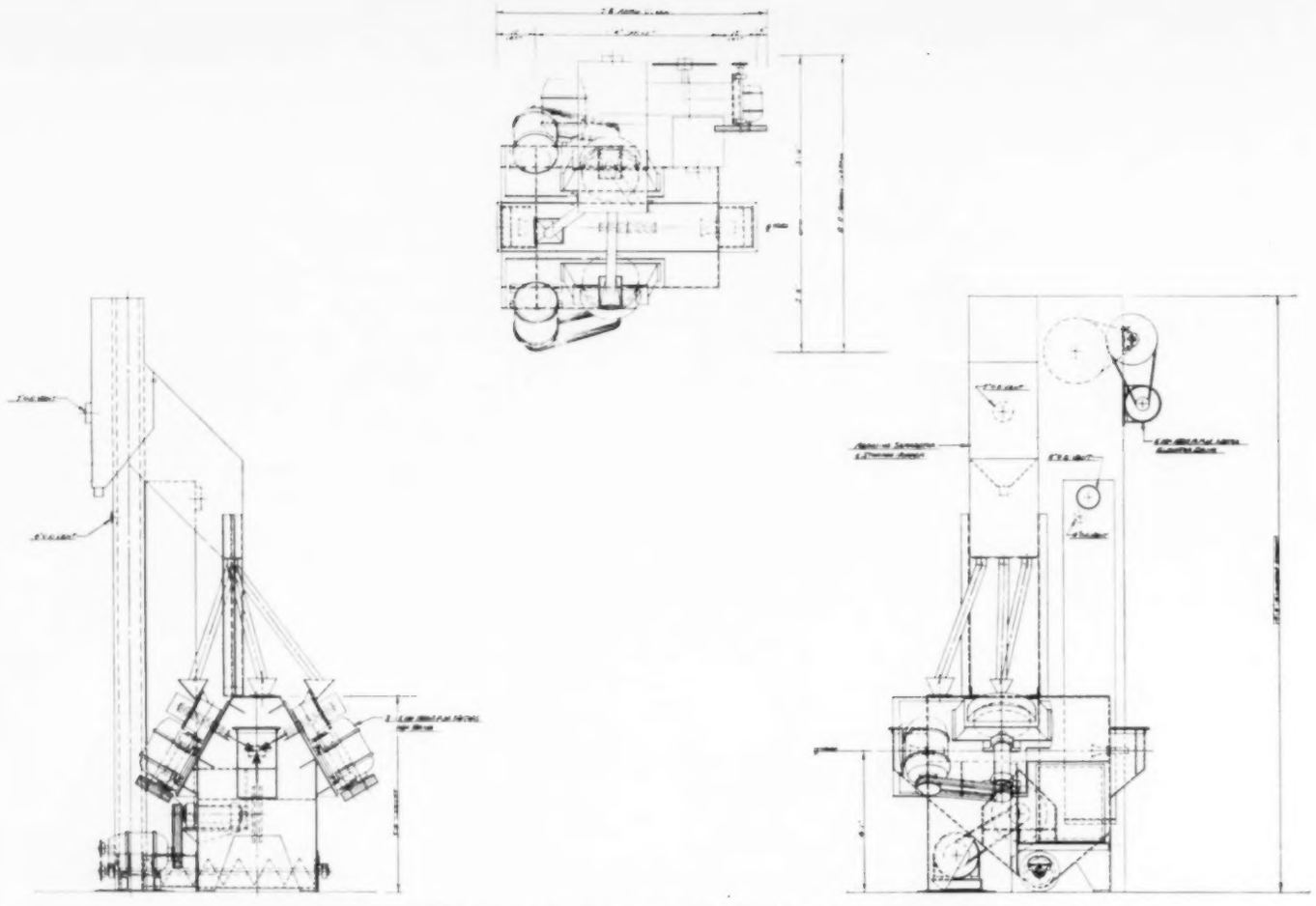


Figure 11 — Diagram of a three-wheel cabinet for cleaning wire rod.

removing close to 100 per cent of the scale because their product must be plated after forming.

BAR STOCK AND EXTRUDED SHAPE CLEANING

Our most important key installation on this type of application is cleaning extruded shapes in bar form in a large steel mill in the Pittsburgh district. The cleaning line is composed of a feeder, blast cleaner and an automatic stacker. See Figure 10. The work conveyor handles five bars at a time at a speed of from 15 to 45 fpm. The mechanical cleaner in this line is a four-unit 19½ × 2½-in. fixed wheel machine with wheels arranged so that all surfaces of the many different sections of extruded bars are covered with the blast and all glass lubricant and scale is thoroughly removed.

WIRE ROD CLEANING

This is a new application for mechanical cleaning and to date we do not have a commercial operation upon which we can report facts and figures. However, one of the largest fastener manufacturers in the Cleveland area has had a 3-wheel machine in operation on an experimental basis for about nine months. The results obtained and the savings predicted decided the question of cleaning facilities in their new plant in favor of this process over acid pickling.

We have known for some time that the 3-wheel method would clean rod satisfactorily for cold drawing. However, we did not know the specific requirements for lubrication and other factors such as cleaning rates, die life, results from multiple hole drawing operations, final finish, and remaining lubrication on drawn wire for cold upsetting operations.

All of these questionable factors have been solved and our customer is installing several units in line with draw-blocks (Figure 11) to secure straight line production from the hot rolled rod to the finished product.

One of these machines has a cleaning rate using 20-hp wheels of 150 to 200 fpm on a single strand, single pass basis. For rod ⅜-in. diam and under where first hole entry speed is high, we can by the use of sheaves secure speeds up to 450 fpm. This is accomplished by passing a single strand under the wheel blast three times.

The following approximate operating costs have been confirmed by test to be nearly correct:

Abrasive — 2 lb. per wheel-hr.	=	$0.25
Spare parts and maintenance labor	=	0.14
Power	=	0.20
Total cost per wheel-hr.	=	$0.59
	times	3
Total cost of machine per hour of blasting	=	$1.77

The cost per ton using 300-fpm cleaning rate on No. 5 rod weighing 0.12 lb. per ft. would be approximately one ton per hour at $1.77 per ton. For No. 1 rod it would be approximately two tons per hour at 88½¢ per ton.

Finally, we are pleased to report similar success on patented rod. These tests are still in progress, but results

indicate that it is now possible to patent, blast clean, coat with borax to prevent rusting, recoil and cold-draw; by-passing the old method of pickling and liming.

STRUCTURAL STEEL CLEANING

We have several machines in operation in this field. Our key installation cleaning structural steel for galvanized transmission towers is in a progressive fabricating and galvanizing plant in Niagara Falls, Ontario. See Figure 12. This customer operates a four-unit 19½ × 2½-in. fixed wheel machine in a conveyor line so arranged that material is moved through the various stages of fabrication by conveyor to the last operation of mechanical cleaning before galvanizing.

The blaster cleans satisfactorily for galvanizing, multiple lengths of small angles up to about two 6 × 6-in. angles. Larger sections such as channels, I-beams and partially fabricated columns are handled one at a time. In addition, this customer operates one of our standard blast tumbling machines to clean small sections such as base and gusset plates, angle clips, tie bolts and other parts requiring galvanizing.

Productionwise, the equipment is presently producing 250 tons per week on one shift operation. The cleaning rate is from 11 to 16 fpm and there is only one operator charged to the cleaning line.

Other interesting facts which should be noted are as follows:

1. The blaster consumes about 30 lb. of cast steel shot per blasting hour at a cost of $4.50 or about 35¢ per ton.
2. Rejects were reduced from 10 to 2 per cent without acid pickle.
3. With a 3-minute acid rinse, they have eliminated all rejects which were caused by too much time in storage, and/or by insufficient blast coverage of the work due to the masking effect of one piece upon another when cleanng more than two pieces at a time.
4. They operate a 60-ft. acid tank having a 10 per cent sulphuric acid bath at 190 F.
5. Since this customer also does jobbing galvanizing on shapes which cannot be handled in the blast cleaner and must be pickled, this 3-min. rinse has not materially affected his costs.
6. They have reduced their labor from 31 men when straight acid pickling to 17 men required for the combination of mechanical cleaning, acid rinsing, and galvanizing.
7. They are using 3½ lb. of zinc per 100 lb. of steel, which provides galvanized protection for 48 years of service as proven by accelerated corrosion tests.
8. The most important savings through use of this combination has been a reduction in dross loss expressed as follows for a 3-month period.

Acid pickling

Average of percent dross to zinc added	20.7
Average lb. dross per ton galvanized	23.3

Mechanical cleaning and acid rinse

Average of per cent dross to zinc added	14.59
Average lb. dross per ton galvanized	18.7

Figure 12 — Cabinet, installed in a Niagara Falls, Canada plant, cleans structural steel for galvanized transmission towers.

ETCHING MILL ROLLS FOR SPECIAL FINISH

Since the publication of our bulletin "Blasting Mill Rolls—1950 Style" which announced the first application of the wheel to mill roll etching, many improvements in the process and equipment have been made.

Etched finishes on cold rolled steel have gradually increased in number. It is not uncommon for us to receive an inquiry for a machine to provide eight or more different finishes on mill rolls. Further, these finishes must meet a definite surface roughness specification in micro-inches as measured by a standard type profilometer.

Due to the large number of different finishes which require different sizes of abrasive and specific setting of control elements, we have developed the following features designed to meet all of the industry's requirements:

1. An abrasive circulating and storage system which will classify all abrasive in circulation, and will supply on demand any size of abrasive within the capacity of the storage facilities.
2. Elimination of nearly all abrasive cleaning in the machine prior to an abrasive change since our new classifier prevents contamination.
3. New electrically operated abrasive volume control which regulates the amount of abrasive thrown.
4. D-c drives and controls to provide infinite variation of finishes through changes of roll rotation and work car travel.
5. Use of our new high capacity wheel and chrome-moly alloy wear resistance parts.
6. A new revolutionary method of supporting and spinning the work rolls consisting of two 18-in. diam. rubber-covered rolls long enough to accommodate the longest work face. The work rolls spin on their work face between these rubber rolls. The roll necks are protected by simple, light weight, molded, slip-on rubber sleeves.

All of these new features combined with our basic design has produced a machine of high production which consistently provides uniform, deeply etched finishes roll after roll.

Our key installation for this application is in a large steel mill whose engineers decided that our blast etching process could be applied to two rolls of matched

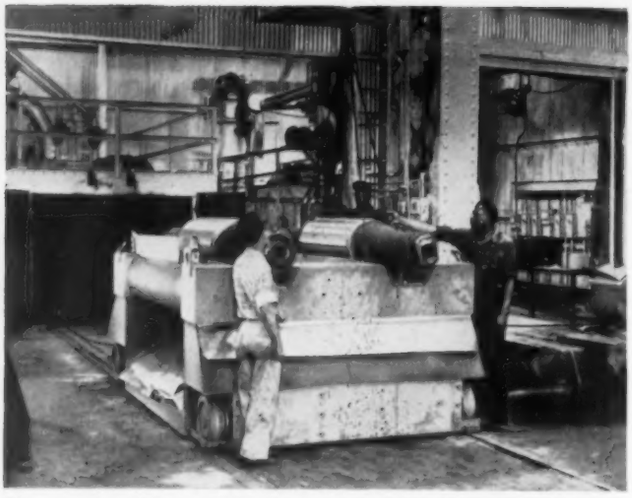


Figure 13 — Two mill rolls are etched simultaneously in this mill roll etching machine in a prominent southern steel mill. Uniform, deeply etched finishes are produced.

hardness in the same degree and time that they were handling one roll. See Figure 13. With their cooperation our engineers produced a two wheel unit which blast etches rolls two at a time. It has been in operation since the first of this year with excellent results.

Basically this machine is the same in detail as our single roll machine except that it is wider, is equipped with two 19½ × 2½-in. wide wheel units and has a wider work car arranged to handle matched rolls in pairs.

Its maximum production is two rolls every 15 minutes or eight rolls per hour. This is broken down into the following operations.

		Minutes
1.	Load work rolls on car and shroud necks	2
2.	Move car 38 ft into blast cabinet and close doors	3
3.	Blast cycle (two passes under the wheels = one cycle). Note this can vary from one to seven minutes	5
4.	Move car 38 ft to unloading station	3
5.	Remove shrouds and unload work rolls	2
	Total	15

This production is easily obtained with one operator and two laborers provided adequate crane service is available. This particular installation is serviced by an electric hoist jib crane, so that the overhead mill crane need only handle rolls to and from the area.

The cost of operating the machine and the cost per roll based on actual values for abrasive consumption and maintenance is estimated as follows:

1.	Abrasive (cast iron grit) consumed, 100 lb. per blasting hour @ 7¢ per lb. =	$7.00
2.	Spare parts and maintenance labor, $1.30 per blasting-hr. =	1.30
3.	Power 50 kwh @ 1¢ =	0.50
	Total per hour	$8.80

Since the actual blasting time is only 20 minutes out of each hour, the net total cost per hour is $2.94, since practically all blasting costs stop when the wheel is not blasting.

The operating labor cost per hour is estimated as follows:

1.	One operator @ $2.25 per hr.	$2.25
2.	Two laborers @ $1.50 per hr.	3.00
	Total labor	$5.25
	Net machine cost	2.94
	Total cost per hr.	$8.19

From the above, the cost per roll on a production of eight rolls per hour is, therefore, $1.02. This is a better than 50 per cent saving compared to the compressed air blast method.

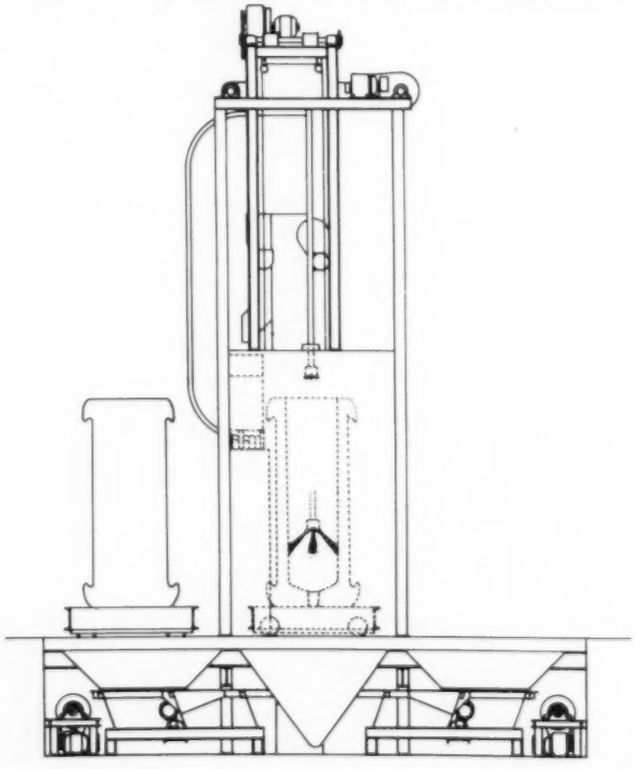
There are a number of intangible savings secured from the following factors, which will further lower cost per roll:

1. Elimination of the human element. Machine is automatic once it is calibrated.
2. Elimination of mill delay through high speed production.
3. Provides a more uniform etch, with maximum penetration consistently, roll after roll.
4. Reduces re-roll tonnage by producing a flatter strip under increased screwdown pressures.
5. Permits faster changeover for different finishes.
6. The percentage of roughened rolls per ton of strip rolled has been reduced, indicating an increase in roll life.

As an example of the versatility of our process and equipment, the following list of standard finishes and the machine control settings will be of considerable interest.

1. *Differential coating finish*
   a. Profilometer specification is 35 to 45 micro-in.
   b. Abrasive used is SAE G-80 cast iron grit.
   c. Wheel abrasive load is 40 amp at 2250 rpm.
   d. Roll is rotated at ½ speed.
   e. Car travel is at ¾ speed.
   f. Blasting time is one cycle (two passes under wheel.)

Figure 14 — Diagram shows special blast cabinet designed to clean and shot peen the interior of forging ingot.



2. *Black plate finish*
   a. Profilometer specification is 80 to 90 micro-in.
   b. Abrasive used is SAE, G-50 cast iron grit.
   c. Wheel abrasive load is 60 amp at 2250 rpm.
   d. Roll is rotated at ½ speed.
   e. Car travel is at ¾ speed.
   f. Blasting time is one cycle.
3. *Matte finish*
   a. Profilometer specification is 85 to 95 micro-in.
   b. Abrasive used is SAE, G-40, cast iron grit.
   c. Wheel abrasive load is 60 amp at 2250 rpm.
   d. Roll is rotated at ½ speed.
   e. Car travel is at ½ speed.
   f. Blasting time is two cycles (4 passes under wheel).
4. *Roughing stand finish*
   a. Profilometer specification is 85 to 95 micro-in.
   b. Abrasive used is SAE, G-40 cast iron grit.
   c. Wheel abrasive load is 60 amp at 2250 rpm.
   d. Roll is rotated at ½ speed.
   e. Car travel is at ¾ speed.
   f. Blasting time is two cycles.
5. *Heavy shot finish—sheet mill product*
   a. Profilometer specification is 125 to 140 micro-in.
   b. Abrasive used is SAE, G-25 cast iron grit.
   c. Wheel abrasive load is 55 to 60 amp at 2250 rpm.
   d. Roll is rotated at ½ speed.
   e. Car travel is at ½ speed.
   f. Blasting time is one cycle.
6. *Light shot finish—sheet mill product*
   a. Profilometer specification is a scatter finish.
   b. Abrasive used is SAE, G-25 cast iron grit.
   c. Wheel abrasive load is 40 amp at 2250 rpm.
   d. Roll is rotated at full speed.
   e. Car travel is at full speed.
   f. Blasting time is one cycle.
7. *Vitro—enamel finish*
   a. Profilometer specification is 185 to 210 micro-in.
   b. Abrasive used is SAE, G-25 cast iron grit screened of all fines.
   c. Wheel abrasive load is 70 amp at 2250 rpm.
   d. Roll is rotated at ½ speed.
   e. Car travel is at ½ speed.
   f. Blasting time is two cycles.

This new modern machine has been operating twenty-one turns a week since the first of the year. Its production is very satisfactory and for those who have a large number of rolls to etch, it offers a fine opportunity to reduce costs.

INGOT MOLD CONDITIONING

With todays stress on improved surface throughout the various stages of steel manufacture, many engineers and operators have believed that improvement should start with the ingot.

One large eastern steel mill is now going to prove this point. They are installing a mold conditioning machine (Figure 14).

This machine, the first of its kind, is a compressed air blast, lance type unit designed to clean and shot peen the interior surfaces of forging ingot molds.

It is rated to produce one mold about every 15 minutes for large size ingots and a greater production as the size reduces. The vertical traveling lance is equipped with four blast nozzles oscillating through 90 degrees. From tests, we have determined a minimum blasting rate of 6 fpm using large cast steel shot. Thus a 6 ft.-0 in. × 36-in. diameter mold would have a blast cycle of two passes for an elapsed time of two minutes. The balance of the 15 minutes is consumed in handling the mold on and off the work car.

From further tests it is believed that periodic treatment of molds with this process will not only produce ingots having a better surface, but will tend to prevent the propagation of fire cracks and thus add to the life of the mold and prevent stickers.

This covers the eight major applications of our process in the steel plants. There are a number of installations performing special jobs such as etching finished products for special finishes, cleaning cut lengths of 6-in. diam. rounds preparatory to cladding with copper, cleaning the edges of pipe skelp for electric weld pipe and others. Space does not permit coverage of these items with factual data.

The above record of achievement is proof that the mechanical cleaning process is one which can increase production, cut costs and in many ways improve product.

DISCUSSION

PRESENTED BY

G. A. LANDIS, Metallurgist—Maintenance, United States Steel Corp., Fairless Works, Fairless Hills, Pa.

GILBERT D. DILL, Engineer in Charge of Steel Div., Wheelabrator Corp., Mishawaka, Ind.

G. A. Landis: Mr. Dill has mentioned the fact that on some of these operations, apparently using shot, a life of 3000 hours is obtained on their wear resisting parts. Do these parts include the vanes or blades on your wheels as well as the wear plates?

Gilbert D. Dill: That 3000 hours covers a general life expectancy for alloy parts. We have blades in our wheels that have lasted 3000 hours, yes; we also have equipment in operation where they arbitrarily take the blades out at 1000.

G. A. Landis: My comment is that 3000 hours service would be in the order of four months continuous service life which sounds like outstanding life for a blade or vane when using either chilled iron shot or grit.

Gilbert D. Dill: I would like to add one thing to clear up this point. That life expectancy is made on the basis of using round steel shot. If you use iron grit, the life expectancy is considerably less because iron grit is very rough on anything that it comes in contact with. However, for etching mill rolls, we have to use the iron grit to get a penetrating, cutting etch on the very hard roll surface. This is normally the only application on which we use chilled iron abrasive.

Using chilled iron grit we would expect a life of around 200 blasting hours of the blades. The alloy liners around the wheels and on the interior walls of the blast cabinet will blast considerably longer.

By JACK M. HESS, Assistant Fuel Engineer
Bethlehem Steel Co., Johnstown, Pa.

CASCADE

▲ A CASCADE control is defined as an automatic control system in which the control units, linked in chain fashion, feed into one another in succession, each regulating the operation of the next in line. Specifically, this paper describes an electric cascade control system which automatically adjusts the furnace control indices of a two-zone continuous billet heating furnace to make proper allowance for the various rates of the mill operation. This system is installed on the 14-in. mill furnace at the Gautier division, Johnstown plant, Bethlehem Steel Co.

The 14-in. mill is a ten-stand, cross country mill which rolls rounds, flats, bulb angles, Tees, Zs, truck rim, small rail, mine ties and numerous other sections. Product sizes from the mill vary from ¼ x 3½ in. flats to 8-in. rounds. Size of the orders vary from 15 tons up.

Due to the many sizes of orders and the many sections that are rolled, frequent size and section changes are necessary. This requires downtime on the mill which in the past created several billet heating problems.

First, the billets leaving the furnace would vary in temperature due to the changes in furnace throughput. The billets at the discharge end of the furnace, after a delay, would be of a different temperature than those that moved through the soaking zone at a steady rate. These temperature differences added to the problem of keeping the finished product within mill tolerances. Excessive scale, slag and scale inclusions, underfills and overfills have been attributed to the non-uniform heating.

The second problem created was the sticking together of billets in the furnace. This varied in intensity with length of the delay and took place between the soaking zone and the heating zone. Here the flame and the flue gas products from the soaking zone washed over the steel passing under the nosing. Many furnace delays were charged against billets sticking in the furnace. Here, again, steel defects were caused by improper heating.

This furnace was originally built in 1924 as a single-zone, side charge, side discharge furnace. It was rebuilt in 1936 as a two-zone furnace. The hearth is flat and measures 56 ft long by 32 ft wide. Billet sizes vary between 3¼ x 3¼ in. x 30 ft, and 9½ x 9½ in. x 30 ft. The average heating rate on this furnace was 25 tons per hour with a maximum peak of 35 tons per hr.

Figure 1 shows graphically the rapid change in rate at which the furnace is required to heat billets for this mill.

To increase the heating capacity and to improve the furnace practice, the furnace was rebuilt in November, 1953.

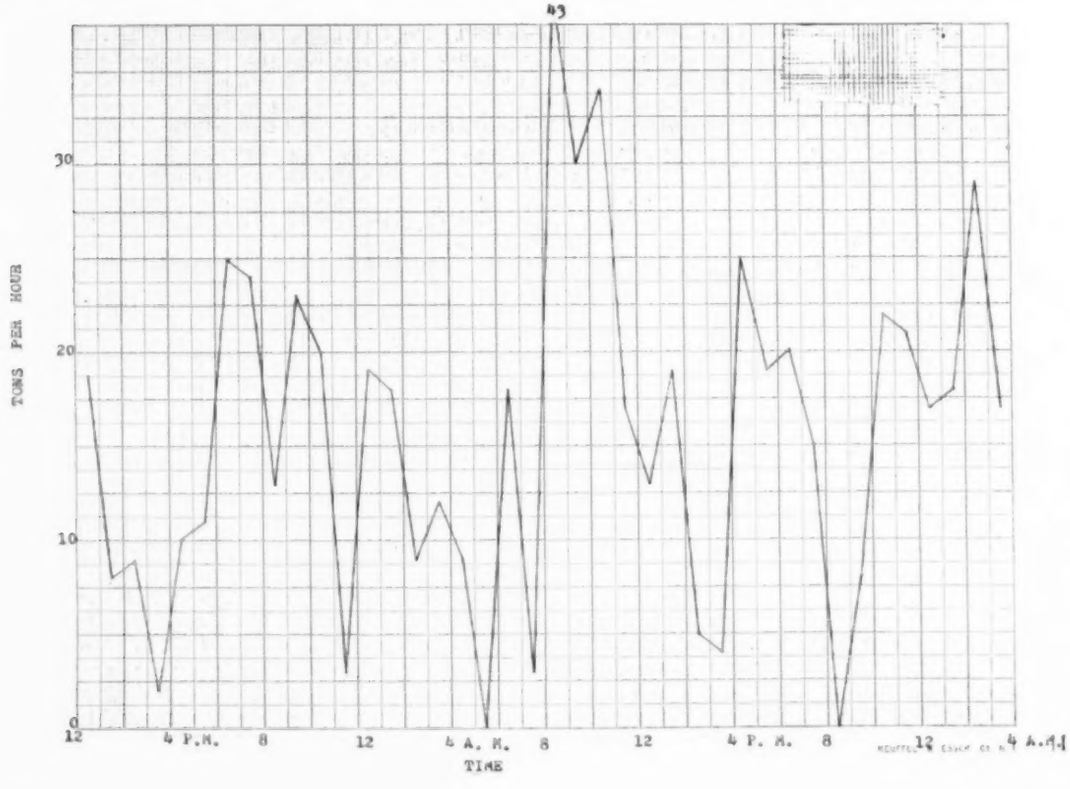


Figure 1 — Chart shows rapid change in rate the furnace is required to heat billets.

. . . . cascade control automatically reduces temperature in furnace when steel movement through unit is slowed down, and readjusts itself continuously from a signal which is sensitive to changes in the operating rate. . . . temperature sensing element in preheat zone is not appreciably affected by flame interference. . . . stickers are reduced. . . .

TEMPERATURE CONTROL SYSTEM on a billet heating furnace

Figures 2 shows an arrangement of this furnace. The only significant change made in furnace design was to increase the opening under the nosing between the heating zone and the soaking zone from 20 to 27½ in. This was the maximum clearance that was possible to obtain and this was done to allow more cross-sectional area for the flue gas products to flow from the soaking zone. During this rebuild, new burners with increased capacity were installed. This required a new combustion air fan, and larger fuel and air piping on each zone. New combustion controls were also added. The furnace has 28 nozzle-mix, luminous-flame burners, 14 in each zone. The maximum firing rate in the heating zone is 150,000 cfhr of coke oven gas, in the soaking zone 80,000 cfhr.

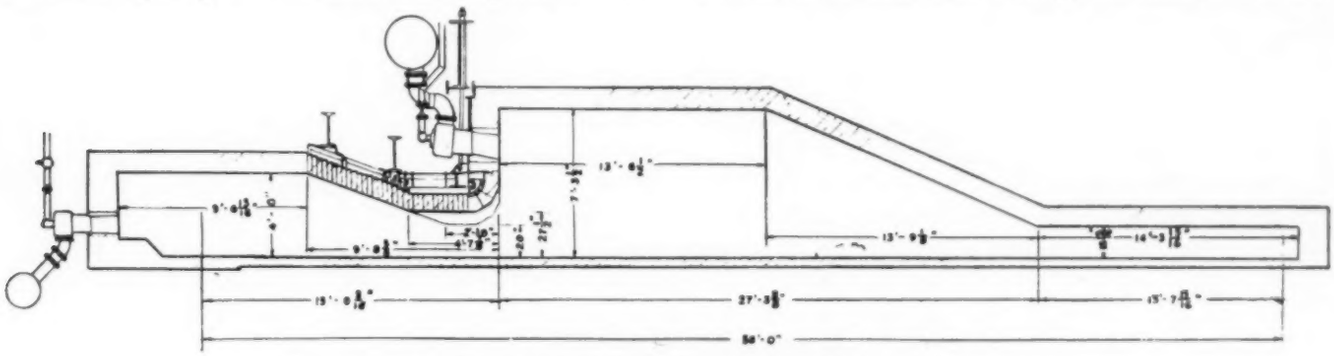


Figure 2 — Diagram shows general arrangement of 14-in. mill furnace.

Table I shows furnace data for the old furnace and the rebuilt furnace. The increased fuel burning capacity was expected to produce a 40 per cent increase in tonnage.

Combustion air is delivered to the furnace at a rate up to 23,000 cfm at 9 in. static pressure. Combustion air is not preheated. The flue products are drawn off by natural draft through a stack. Furnace pressure is maintained at +0.04 in. water column at the discharge end of the furnace.

Figure 3 shows the front of the panel house. On the panel are the following pieces of equipment: billet temperature recorder, gas pressure and furnace pressure recorders and controllers, heating and soaking zone recorders-controllers, air flow and gas flow recorder-controllers for the heating and soaking zones, and preheat temperature recorder-controller.

The outstanding innovation of this furnace is the installation of a temperature control system with automatic zone temperature setting for mill delays. The purpose of the cascade control system is to readjust the furnace control set point to make proper allowance for the rate of material flow through the furnace. For the purpose of discussing this control system, the furnace is considered to be divided into three zones; the soaking zone, the heating zone and the preheat zone.

Figure 4 shows the location of these zones. There is a distance of 15 ft from the center of the discharge door to the base of the heating zone burner wall, and this

TABLE I
14-in. Mill Furnace Data

	Old furnace	Rebuilt furnace
Sq ft hearth area	1824	1824
Furnace volume, cu ft	6484	6551
Fan capacity	14,000	23,000
Maximum gas flow—cfhr	150,000	193,000
Average gas flow—cfhr	126,000	154,000
Maximum M Btu per hr	80.5	104
Average M Btu per hr	67.5	82.5
Maximum tons per hr	35	50
Average tons per hr	25	35
Maximum lb per hr per sq ft hearth	38	55
Average lb per hr per sq ft hearth	28	38

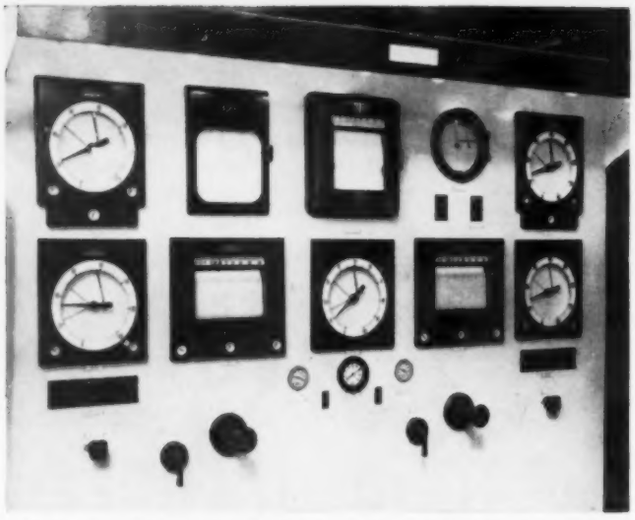


Figure 3 — Panel on front of the panel house includes billet temperature recorder, gas pressure and furnace pressure recorders and controllers, heating and soaking zone recorders-controllers, air flow and gas flow recorder-controllers for the heating and soaking zones, and preheat temperature recorder-controller for furnace No. 14.

length is considered to be under the influence of the soak zone burners. The length of the heating zone is considered to be from the end of the soaking zone to the low end of the heating zone roof slope which is 27 ft. The preheat zone is considered to be the flat roof section extending from the heating zone to the charging roll, a distance of about 13½ ft. The height of the above zones are 4 ft, 7 ft-3½ in., and 19 in. respectively above the hearth. The temperatures of the heating and soaking zones are measured by roof radiation units sighting into closed end tubes. The preheated steel temperature is sensed through an open and sighting tube.

Preheat temperature of the material near the charging end of the furnace is a good indication of the rate of material flow through the furnace. If the temperature is measured at a fixed distance from the end of a continuous furnace of conventional design, it will sense a low temperature when material is moving at full operating speed. Upon a delay, temperature of the steel will increase and approach the temperature of the exit gases. It is this variation in temperature which is employed as the setting means for the cascade control system. For most furnaces, this will be between 1000 and 1400 F at the charging end. The point of temperature sensing should be some distance from the charging end to prevent undue influence of the charging operation. A distance of 10 ft has been found to be adequate on this furnace. It must be kept in mind that the distance the preheat sensing element is advanced along the direction of material flow, directly determines the time before cold material will reach this element after a delay. For example, if a radiation unit were mounted ten ft from the charging end, it would sight, during a mill delay, on high temperature material. After resuming operations, this ten ft of material will be at the delay temperature, and thus prevent heating and soaking indices from rising to operating level until this material has been pushed ahead of the sighting element's field of view. This would permit an equivalent amount of thoroughly heated material to be discharged before the indices are automatically advanced.

On a scheduled delay, the furnace operators can better perform the index adjustment themselves, because they can anticipate the accumulation of heat in the furnace and actually cut back the heat 15 or 20 minutes before the control would. In doing so, they keep the material below operating temperature, knowing that it will not be needed.

After the rebuild of this furnace and prior to installing the cascade control, the following steps were taken to establish a factual background for automatic cut-back requirements based on measurements made during normal manual regulation.

1. Preheat charts were analyzed for repeatability and response by direct observation of a few hours at a time and indirectly for several weeks by plotting hourly tonnages and the preheat temperature indication. See Figure 5.

2. Composite graphs were made of preheat temperature, hourly tonnage, heating and soaking zone control records. In this case, the heating and soaking zone temperatures were set by the operators without electric index drive (Figure 6).

3. The total amount of index cut-back that the operators would make when holding the steel ready for rolling during delay or trial bar periods was carefully noted and averaged for several of the operators.

4. After stops in operation, observations were made of the time elapsed before the steel could be considered soaked and required full cut-back.

5. The time and amount of cut-backs were noted and compared with the amount of temperature rise in the preheat zone for the same period of time.

Figure 7 shows schematically the operation of this cascade control. On delays or slow rolling, the steel under the influence of the preheat zone increases in temperature. This is sensed by the preheat temperature

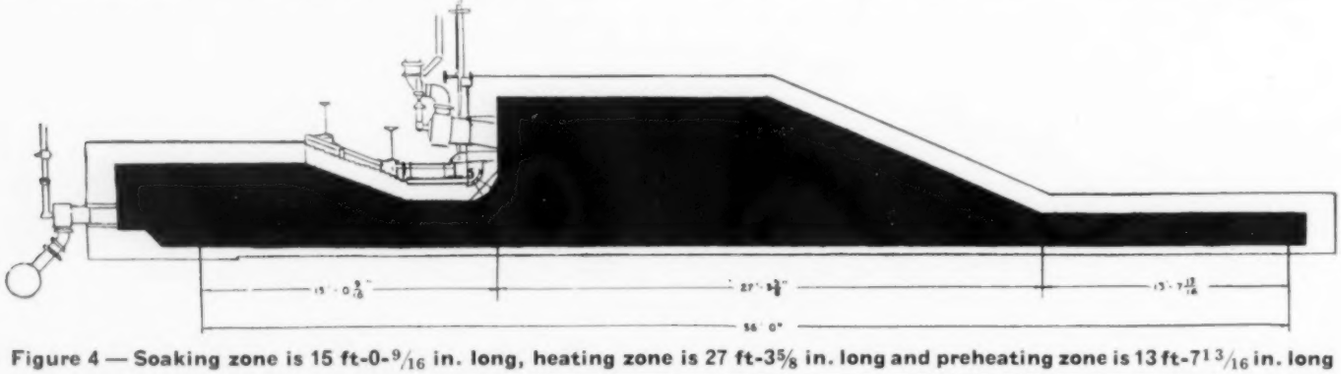


Figure 4 — Soaking zone is 15 ft-0-9/16 in. long, heating zone is 27 ft-3⅝ in. long and preheating zone is 13 ft-7 13/16 in. long

Figure 5 — Curves give tons per hour and preheat temperatures during normal manual regulation.

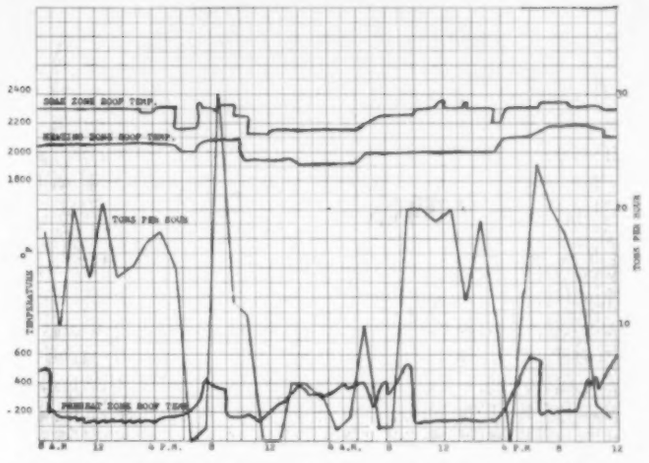


Figure 6 — Chart shows preheat temperature, hourly tonnage, heating and soaking zone temperatures with heating and soaking zone temperatures set by operators without electric index drive.

transmitter, which proportionately lowers the set point of the soaking zone controller by means of an electrical rebalancing system. The heat head above the steel in the soaking zone is thus reduced to avoid overheating. This action also slows up the temperature rise in the preheat section which has caused the lowering of soaking zone set point. Maximum and minimum limits for automatic movement of set point are provided in the controller. The maximum limit establishes the highest allowable furnace temperature under the heaviest charging rate. The minimum limit establishes the lowest temperature necessary to maintain steel at the proper rolling conditions following extensive mill delays.

As a means of providing the furnace operator with ability to establish any normal zone temperature desired for various grades of steel, the panel mounted relay which functions to automatically move the set point from changes in charging rate, is calibrated in degrees for use in such manual setting.

The temperature set point of the heating zone controller is also automatically established, and varied by temperature condition in the preheat zone, by means of a similar electrical proportioning system. The setting, in this case, is established by the soaking zone temperature, and for the furnace operator the intermediate relay is calibrated to read the approximate desired difference in temperature between soaking and heating zones.

Figures 8 and 9 show two charts covering the operation of this control. Figure 8 shows the preheat temperature indication chart. Note on this chart that at about midnight the preheat temperature indication increased above the minimum level (350 F on the preheat band) and stayed above this point until some time after 3:00 am. Figure 9 shows this portion of the preheat chart along with the heating zone and soaking zone temperature charts for the same period of time. The temperature curve at the right is that of the soaking zone. During normal rolling, the control temperature was approximately 2100 F. At midnight, due to mill delays, the preheat controller reduced the temperature in the soaking zone to a value of approximately 2030 F. This was con-

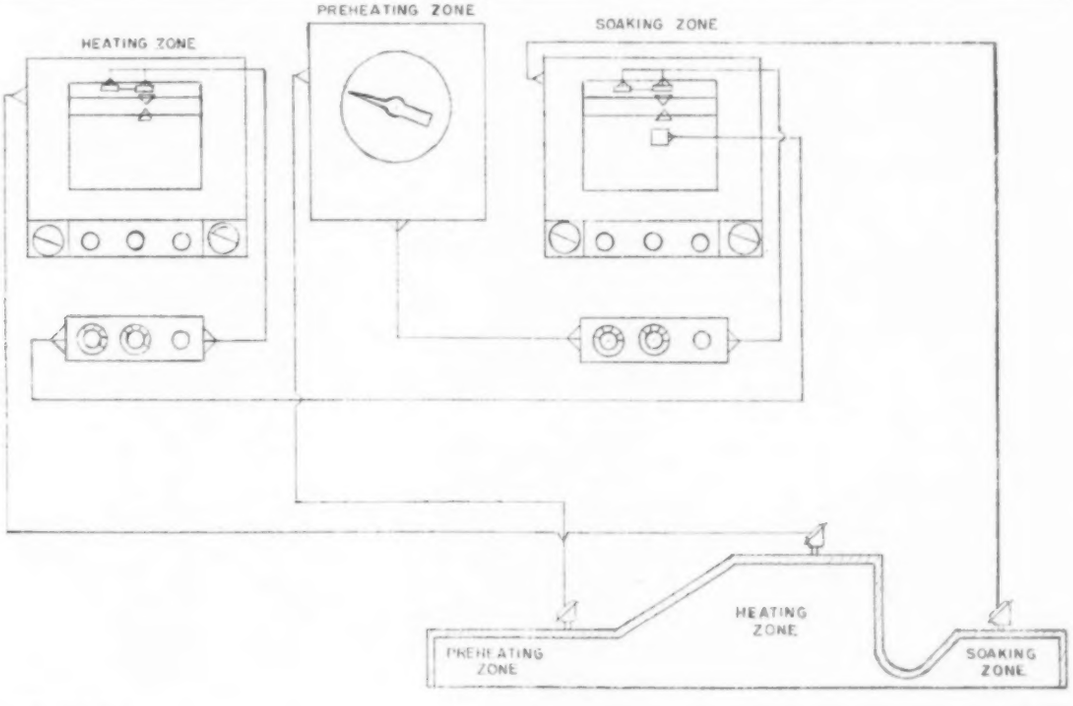


Figure 7 — Schematic diagram of operation of cascade control.

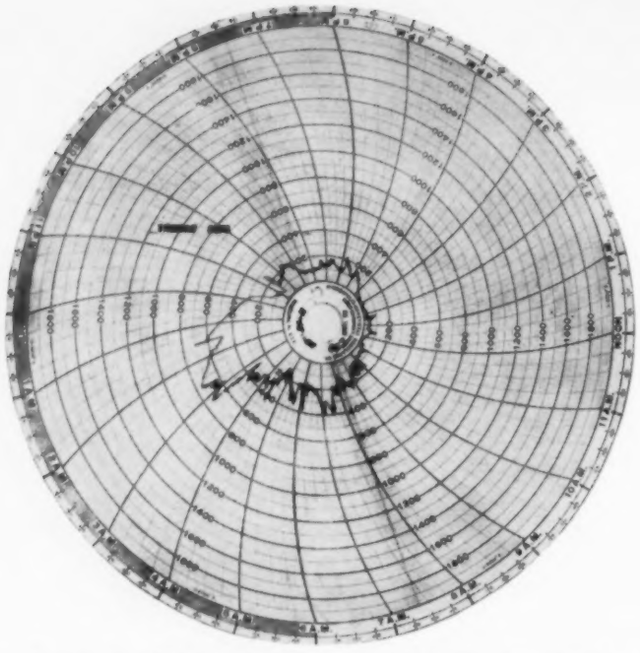


Figure 8 — Preheat temperature with cascade control.

tinued until about 3:00 am when normal rolling was resumed. The center section of Figure 9 shows how the heating zone follows that of the soaking zone, and that the control temperature of that zone is approximately 200 F lower than that of the soaking zone.

Differences in product temperature between the 14-in. mill furnace and a similar furnace without cascading controls have been observed on numerous occasions. The 14-in. mill furnace maintains even rolling temperature of the billets when stops on the mill are under one hour duration. Rolling temperatures of the furnace without cascading control, on the other hand, vary as much as 100 F after delays on the mill. This is shown on Figure 10. This figure compares billet temperature charts taken from the 13-in. mill and the 14-in. mill. The left side is representative of the 13-in. mill and the delays in rolling are reflected in the temperature of the billets as they pass through the mill. On the other hand, the 14-in. mill billet temperatures, even with mill delays, are quite uniform and show no effects of the mill delay.

It is for the following reasons that preheat cascading is of value:

1. A higher furnace temperature is required to heat steel for rolling when steel is moving steadily through a furnace than when it is stopped or is moving slowly. Cascading automatically accomplishes this.
2. A heat cannot follow each change in operating rate because of various other duties, so he must make step-like changes in furnace temperature settings based on a mill rate prediction. Cascading readjusts continuously from a signal that is sensitive to changes in operating rate.
3. It is difficult to accurately sense the steel temperature in the heating zones directly due to flame interference and non-uniform material lengths. Cascade control overcomes this problem as the temperature sensing element in the preheat zone is not appreciably affected by these conditions.
4. A degree of uniformity of procedure is possible when preheat temperature initiates cut-back as compared with the different timing habits of each heater.
5. The sticking of billets is a problem with many grades of steel. To prevent this condition, it is necessary to reduce furnace temperature during delay periods. Cascade control performs this function automatically.

It is apparent that the temperature compensation made by operators on the non-cascading type equipment, although adequate in most instances, cannot match the accuracy of the cascade type system.

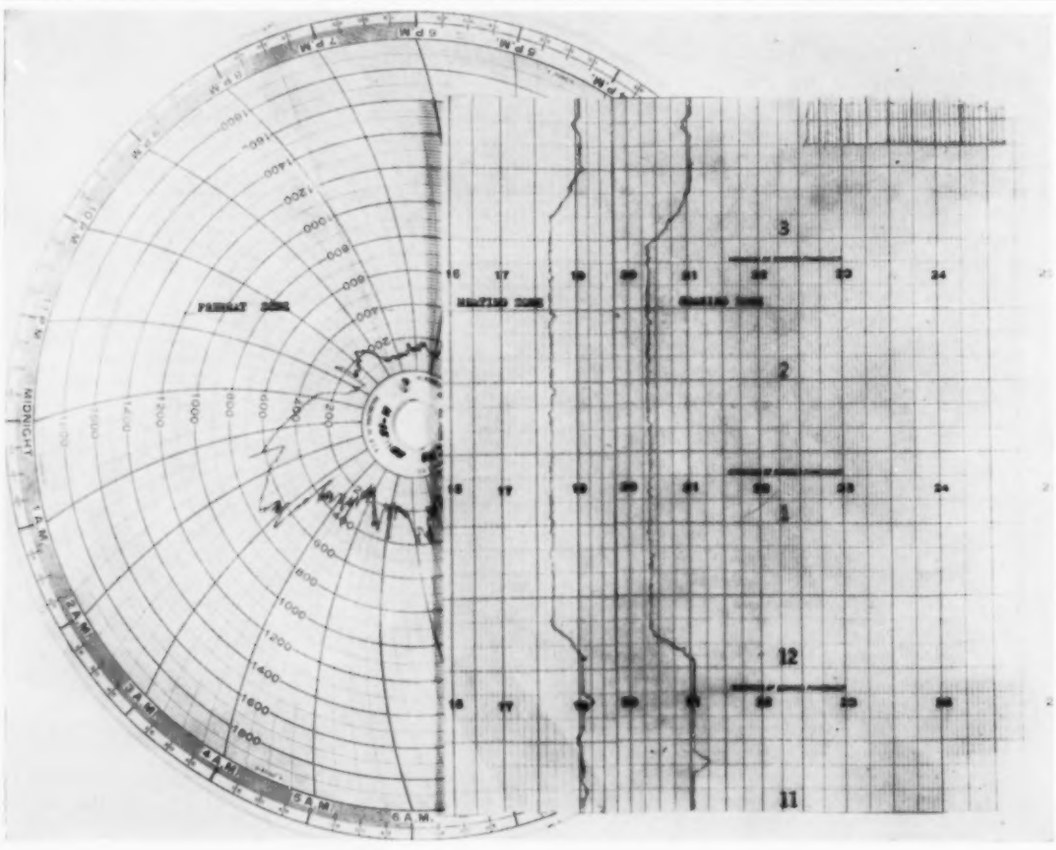


Figure 9 — Chart shows preheat zone, heating zone and soaking zone temperatures with cascade system.

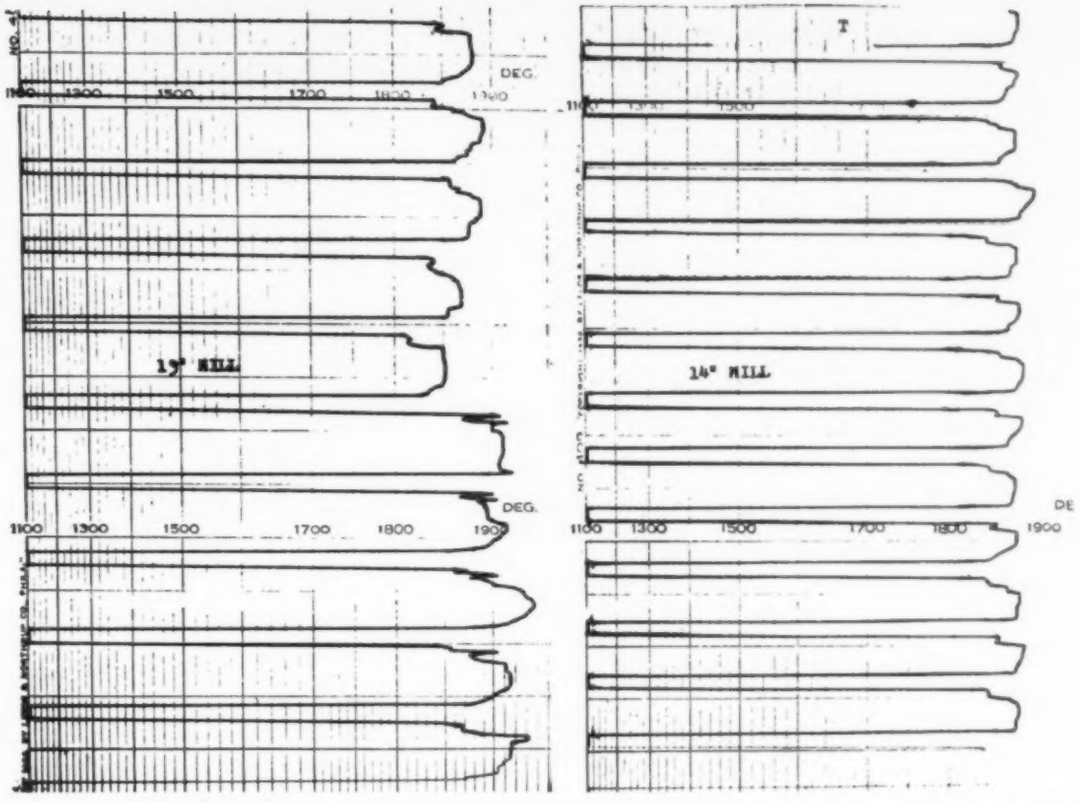


Figure 10 — Charts compare billet temperatures from the 13-in. and 14-in. mill. Delays in rolling on the 13-in. mill (without cascade control) are reflected in the temperature of the billets as they pass through the mill (left side); temperatures of billets from the 14-in. mill are quite uniform and show no effects of mill delay.

The benefits that have been obtained by the use of this control can be summarized briefly as increased production and improved quality.

The increased production is a result of reduced furnace delays. Since this control has been in operation billet sticking has been a rarity. In the few instances where billets have stuck together the difficulty has been of a light nature and the billets have been easily separated.

Improved quality of the product off the mill is the result of uniformly heated billets leaving the furnace and the elimination of overheated and excessively scaled billets.

DISCUSSION

PRESENTED BY

FRED S. BLOOM, President, Bloom Engineering Co., Pittsburgh, Pa.

JACK M. HESS, Assistant Fuel Engineer, Bethlehem Steel Co., Johnstown, Pa.

E. T. W. BAILEY, Chief Combustion Engineer, The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada

ROBERT W. QUINLAN, Fuel Engineer, United States Steel Corp., Central Operations, Fairless Works, Fairless Hills, Pa.

FRED C. SCHOEN, Chief Engineer, Alan Wood Steel Co., Conshohocken, Pa.

JOHN GREEN, Manager, Steel & Ceramic Dept., Minneapolis Honeywell Regulator Co., Industrial Division, Philadelphia, Pa.

C. R. ELLSTROM, Assistant Combustion Engineer, Jones & Laughlin Steel Corp., Pittsburgh Works, Pittsburgh, Pa.

Fred S. Bloom: Mr. Hess describes the difficulties in operating his furnace and attributes part of the reason for going to the cascade method of temperature control, which is based on measuring furnace temperature, to the fact that he finds it impractical to measure steel surface temperature. However, if we analyze his operation carefully, we can arrive at a number of factors which make the operation of the heating process very difficult; namely:

1. He has a furnace which has approximately 1600 sq ft of heating surface, which by normal standards, should be capable of heating 80 tons of steel per hour, while he states that his maximum tonnage is 35 tons of steel per hour. This slow rate of heating, plus variable rate of heating, can cause many of his problems which are quite different from operations on many of our triple-fired furnaces which heat at almost a continuous rate in tons per hour when operating and never attempt to heat at slow rates. The success of this system must be studied with this factor in mind.

2. The wide variation in thickness of the product heated in the furnace is a difficult operation; namely, that the author heats billets from 3¼ to 9½ in. thick in a top-fired furnace which means that unless extreme caution is taken, the temperature of the bottom side of the billet will never equal that of the top side on the thick material.

3. An analysis of the furnace temperature and the heating rate indicates that the surface temperature of the billet follows furnace temperature very closely. The maximum temperature difference between furnace temperature and steel temperature is probably not over 150 F at any spot from the middle of the furnace to the discharge point. This means that if any high furnace temperatures or hot spots exist, then surface temperature will follow these hot spots and sticking of the billets will result.

From the above three items, it is quite obvious that the solution of Mr. Hess' problem is not a simple one, because accurate steel surface temperature is difficult to measure if the furnace temperature and the steel surface temperature are close together. Thus, we can see the reason for having his so-called soaking zone at a higher temperature than his main heating zone, which again is contrary to most of our heating practices.

I am glad to see the emphasis which Mr. Hess gives to the problem of preventing the superheating of the steel at the charging end of the furnace during mill delays. The correction of this condition in all continuous furnace operations should help to correct many of our operating difficulties. The importance of this condition can only be realized when we analyze Mr. Hess' operation and realize that some of his material is in the furnace for at least nine to ten hours and that whatever happens during the first hour can upset the entire operation for the next seven or eight hours.

I would like to ask Mr. Hess one question; namely, In his opinion, can the cascade type of temperature control be applied to control a triple-fired furnace operating at high rates of production?

Jack M. Hess: I want to thank Mr. Bloom for further describing our heating problem. An additional factor is that many billets are brought out of the furnace, cut in half or thirds for rolling, with the remaining portions placed back in the discharge end of the furnace for subsequent rolling. This practice reduces the throughput of the furnace.

To answer your question, I believe this type of temperature control could be applied to any furnace whether it is a high-rate triple-fired furnace, or one such as discussed here. The benefits derived will, however, be inversely proportional to the uniformity of the mill operations.

E. T. W. Bailey: The application of cascade temperature controls to a billet heating furnace is an interesting development. Mr. Hess' description of the system used is very clear and gives promise of an improved operating tool. One wonders why we have not thought of this application before.

We confirm from our own tests his statement that "if the temperature is measured at a fixed distance from the end of a continuous furnace of conventional design, it will sense a low temperature when material is moving at full operating speed." This means he has found a sound basis for fuel indexing.

I would like to ask:

1. What automatic features he used in the instruments?

2. Has he considered the use of this system for slab furnaces?

We use a temperature cascade control system on the new electrically heated continuous anneal furnace. Here one master sights on the strip as it leaves the soaking zone and indexes eleven heating zones. In this furnace the first two zones of heating are directly controlled.

The next four zones (3–6) are indexed from the master control, but have an on-off control action.

The next seven zones (7–12) are indexed from the master and are equipped with 0–500 per cent proportional band adjustment automatic reset and rate action. The master control has the same features as instruments on zones 7–12.

The control system works very well, the chief difficulty being lack of an accurate and rapid means for checking the accuracy of the master control radiation unit, sighting on the bright strip. Indirect means of making this check are available and seem to be satisfactory under favorable conditions.

Another application of cascade temperature control is being installed on a new wire galvanizing and lead annealing line. Here the master control receives its impulse from the metal temperature and in turn pneumatically indexes the pyrometers measuring the temperature of the products leaving the combustion chambers. Limits are selected for indexing. It is hoped that longer pot and refractory life will result, as well as less variation in zinc and lead temperatures.

Jack M. Hess: The zone temperature controllers are equipped with proportional band adjustment and automatic reset. These functions are not affected by the temperature cut-back system. The preheat-controller functions in series with the index drive motor and drives it at a constant speed. This act is identical to changing the temperature control point with the manual setter knob, which makes no change in the proportional band or reset rate.

We have no triple-fired slab heaters. However, as in the answer to Fred Bloom's question, I believe that it would be a useful operating tool.

Robert W. Quinlan: The cascade temperature control system is a great step directed toward automation, a program we are all very much interested in today. The cascading or automation of all instruments and control processes must be taken into consideration on all rebuilding, expanding or new installations.

The government informs us that in the next few years we will be faced with a serious manpower shortage in industry which can only be offset by the use of automatic control to the fullest extent. I think we can produce a better product, faster, cheaper, and with less manpower by use of automation.

In using the temperature of the material near the charging end of the furnace, Mr. Hess has found an index to reset the entire control operation of the furnace. The factor is derived from temperature, speed and distance. It is noted that the distances the preheat sensing element is advanced in the direction of material flow, directly determines the time it will take cold material to reach the element after a delay. Also noted is a means for the furnace operator to establish various normals for the various grades of steel by means of a relay calibrated in degrees and controlling the soaking zone control. The difference in temperature between the soaking zone, and heating zone is adjusted by means of an intermediate relay, also calibrated in degrees.

The difficulty in getting an accurate temperature of the steel in the heating zone is overcome by the use of the preheat sensing element as it is not affected by the interference of flame.

The point I wish to bring up is the amount of change in the fuel-air ratio and furnace pressure during a delay.

It has been found that, during an extensive delay the amount of combustion air should be increased and the furnace pressure should be adjusted to hold infiltration at a constant value. This is the answer to sticking billets.

To sum up, I believe the cascade control is an answer to a better product, faster and cheaper, with less manpower.

Jack M. Hess: The fuel-air ratio remains constant over the firing range. On this furnace we have fuel-air volume flow control which compensates for any pressure fluctuation in the fuel or air systems.

Furnace draft has been no problem as the furnace pressure control has been able to maintain a positive pressure in the hearth, even at low flows.

Fred C. Schoen: I appreciate that we are used to using the words *soaking zone* for the last zone, but on the furnace described the last zone seems to me to be more of a heating zone than a soaking zone. This shows up with a fuel input maximum of 80,000 cfhr in the soaking zone and 150,000 cfhr in the heating zone. I also feel that this helps cause the tendency toward sticking which you get at the transition point.

All this brings up a question in my mind: If this last zone is a heating zone and the cut-back control is located about 10 ft from the charging door, I wonder if you have tried a cut-back control for the first firing zone located very close to the charging door? It would seem that such a location might permit additional fuel application in the first heating zone before the final zone picked up, and thus smooth out the temperature swings within the furnace. At the same time, it could help, I believe, in eliminating the minor tendency still experienced toward sticking.

A final question, when changing sizes, do you go from the minimum to the maximum cross section in one step or do you try to make the change in small increments, and how does the furnace respond to these conditions?

Fred Bloom brought up a point about the control. We put on a slab heater back in 1949, with what we called an anticipating control. We were set up to charge cold slabs and also to swing in with hot slabs depending upon mill operation. I have to confess we were never able to make it work, because we never got the furnace up to enough capacity to really get a good test. Ours seemed to work in the opposite direction, but because we did not have enough capacity in the furnace, we could not make it work. Mr. Bloom brings up the point here that with the overcapacity in the furnace it seems to be working. I confess, I am trying to find an answer to this myself.

Jack M. Hess: Getting back to some of the things that Mr. Bloom mentioned and the questions you asked, the distance from the heating zone to the discharge door is 15 ft, and it would take a good hour's rolling to move the steel from underneath that burner wall to the discharge door, and as you saw in our first chart on the changes in rates that we heat for this mill, sometimes we do not have runs that long. Other times they are longer. So, for that reason, we have to use the soaking zone as an additional heating zone, and the reason for picking the preheat temperature to operate from the soaking zone first and then following that by the heating zone is, that we can first protect the steel that is passing under that nosing and, second, that we can keep it ready for rolling as it comes out of the soaking zone.

I did not quite get your question on the location of the sensing element.

Fred C. Schoen: I felt that if there were a sensing element a couple of feet from the charging door which operated on your first firing zone, that you would not be waiting necessarily to start picking up the temperature in the firing zone until you reached the sensing element which you presently have located about ten ft away. It seems that with the heavier sections coming through, picking up that zone a little sooner, you would not have to pour as much heat into the final zone.

Jack M. Hess: That could possibly be true in some cases, but the over-all picture—and we have studied it from all angles—indicates that we are doing it. As far as the grades of steel and the size of orders we are rolling, the soaking zone cut-back seems best for our plan.

Fred C. Schoen: I figured this in addition to your soaking zone control.

Jack M. Hess: That may be something to consider. As to changing sizes on the mills, we have no set pattern of changes. Rolling schedules are made by the order department and are governed by steel and rolls available, and scheduled delivery of steel to the customer. On this mill, steel can be finished from the fifth stand or the tenth stand; thus, a slight change in the mills can effect a large change in the size of billets heated. This furnace with its preheat sensing control responds very well to the changes in billet sizes, and to the changes in mill production rates.

John Green: First, the difficulty of the problem as brought out by Fred Bloom is magnified, obviously, by the type of product that is going through the furnace, and the great rate in tonnage change for which the furnace is designed and must supply. Therefore, as he pointed out, considerable thought was given in the design of the system to provide all the flexibility possible. In many cases, the actual system as installed is not required in all of its functions today, largely because of the location that has been mentioned of the temperature sensing point in the preheating zone to balance out the amount of time, regardless of rate at which the furnace is charged to correspond with the time which the steel is held in the soaking zone.

The system as originally designed was laid out so that the temperature rise on an increasing charging rate through the furnace could be slowed up to be exactly in keeping with the charging rate. It was found by the location of this sensing point, however, that that feature could be eliminated and, therefore, this makes the installation applicable both to an electrical index drive point or to a pneumatic index drive point with equal ease.

Another point, the question was asked concerning a blocking or locking of either furnace pressure or fuel-air ratio controls. I know that the equipment as supplied is designed so that the fuel-air ratio is automatically maintained as the temperature of the furnace is lowered during mill delay or low rolling periods.

The basic feeling, after the design of this particular system of cascade temperature control, is that it is equally applicable to a higher tonnage charging rate and more continuous operation as far as tons per hour are concerned, and it is all designed to eliminate as much as possible the outguessing of mill delays and charging rates by the operator, and functioning for

furnaces which do require, as a high majority do, a temperature measurement of furnace conditions rather than a direct measurement of steel temperatures where, if that can be done in a furnace, it eliminates to a large extent the need for such a cascade system.

C. R. Ellstrom: In view of Mr. Bloom's remarks on Mr. Hess' problem, it can be said that Mr. Hess has certainly presented an interesting and provocative picture of the cascade temperature control system, a fulfillment of necessity and it's subsequent operation.

There are a few questions that come to mind regarding component parts of the system as well as several questions on the furnace.

The question on the instrumentation concerns the method used in taking the temperature of the furnace with portable equipment, when checking or setting the recorder-controller instruments. In the case of the heating zone and soaking zone radiation units, do you try to sight on the end of the target tube or on an area of the roof immediately adjacent to it? If this checking is done, how often do you find it necessary to do so? Also, since you say that the preheat zone temperature is only relative, do you make any check of it?

It would be interesting to know if you find it necessary to clean the preheat zone radiation unit very often since it sights through an open-end tube directly on the steel, or have you made provisions for keeping it clean, such as a sealed head or air purge?

A final question in the instrument category concerns the target tubes. Are the ends flush with the roof, protruding into the furnace, or recessed in a truncated cone shaped opening in the roof?

In regard to the furnace design: do you believe an overhead waste gas discharge flue would have any detrimental effect on an installation such as yours?

As a matter of general information, it would be of interest to know how long it took to correlate the data concerning operation, delays, sections rolled and so forth before your rules of operation could be set up for the heaters.

When operating at a furnace pressure of plus 0.04 in. water column what kind of a condition do you experience at the doors and other furnace openings?

Also, do you allow your heaters to use compressed air on your end burners, or are you not suffering from the problem of hot ends?

Finally, did you really attain the anticipated 25 per cent increase in your tonnage with the increased fuel burning capacity?

Jack M. Hess: We check the roof temperature radiation units weekly and do this by removing the element and sighting into the closed end tube with an optical pyrometer. We clean the preheat radiation pyrometer weekly and check the preheat controller balance motor monthly. All radiation units have an air purge. The target tubes for the roof units protrude one inch into the furnace.

With regard to furnace design, I would say that an overhead waste gas discharge flue would have no effect on this installation as we sense the preheat temperature far enough ahead of this point.

As to correlation of the data, we had ample time to do this. We had the furnace rebuilt several months before the cascade control equipment was received and installed. I believe that two or three weeks of data collecting would be sufficient to set up the procedure.

Furnace pressure is controlled at +0.04 in. water column and this gives a slight pressure at the discharge doors and the doors along the sides of the furnace. The conditions at the charging door vary considerably from the heavy blow to slight suction. This condition is affected by the steel being placed over the flue area.

No compressed air is used on any burners. The end burners in both zones are cut back slightly to prevent hot ends.

As far as the anticipated 25 per cent increase in tonnage, all I can say now is that we will be able to heat it any time the mill can roll it. This mill is to be rebuilt and after that we may be called upon to heat at the increased rate.

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modern techniques in the COLD REDUCTION OF SHEET AND TIN PLATE

By

E. N. ARCHIBALD

Assistant Superintendent

Cold Reduction Dept.

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United States Steel Corp.

Pittsburg, Calif.

▲ BEFORE discussing modern techniques in the cold reduction of sheet and tin plate products, perhaps it would be well to give a brief description of the sheet and tin mill operations at Pittsburg works.

The sheet and tin mill is divided into three operating departments—the cold reduction department, the tin finishing department, and the sheet finishing department. Facilities are designed to finish hot strip coils which are produced at the Geneva Works. Products in the sheet and tin mill are electrolytic and hot dip tin plate, black plate, hot and cold rolled sheets, and galvanized sheets.

The operations that are performed in the cold reduction department are continuous pickling, cold reduction, electrolytic cleaning, and annealing. Cold reduction involves the rolling and stretching of steel strip to a predetermined gage through a series of rolling mills set in tandem, each mill having been preset so that the reduction in gage is proportional to increases in mill speeds from stand to stand throughout the mill until the predetermined gage is attained at the exit end of the last stand. The purposes of cold rolling are to reduce thickness, to produce a smooth, dense surface; and, with subsequent heat treatment, to develop controlled mechanical properties.

The first mill installed at Gary tin mill was put in during the summer of 1931, and started cold reduction about October 23, 1931. This mill had 16 x 42-in. work rolls and 49 x 42-in. backup rolls. It was not a reversing mill, but had removable sleeves which could be transferred from the coiler to the uncoiling shaft. The maximum output for this unit was between 15 and 20 tons per 8-hr turn.

In the summer of 1933, a second mill was installed. This was a 42-in. wide mill of the reversing type. The coils were handled on drums with self-contained roller bearings which locked in position on each side of the mill. The original mill installed two years before was then converted to the reversing type. The output of these units on tin mill gages was much higher than on the original unit.

One is able to appreciate the tremendous progress that has been made, when these early mills are compared with the installation at Pittsburg, California, shown in Figure 1, a five-stand tandem mill with a maximum speed of 4100 fpm and 16,300 hp which was installed in 1948. A new five-stand tandem mill recently erected at the Fairless Works of U. S. Steel has 23,500 hp and a top rolling speed of 7000 fpm.

Figure 1 — The five-stand tandem mill shown, installed in 1948 at Pittsburg, Calif., has a maximum speed of 4100 fpm.

Some idea of the power and pressures required in the cold reduction of sheet and tin plate products can be conveyed by describing briefly some of the mechanical and electrical features of the five-stand tandem mill. This mill consists of five identical stands. The stand housings are of heavy cast steel construction, weighing approximately 120 tons each, with a post area of 870 sq in. and 1½ in. thick steel window liners.

The roll arrangement in the five-stand tandem four-high cold reduction mill is shown in Figure 2. All rolls are supported by the bottom back-up roll which in turn is supported by the mill housing. The work rolls are 21½ in. in diameter, with a 56-in. face. The backup rolls are 53 in. in diameter, with a 55-in. face, and are equipped with oil-film radial bearings and roller thrust

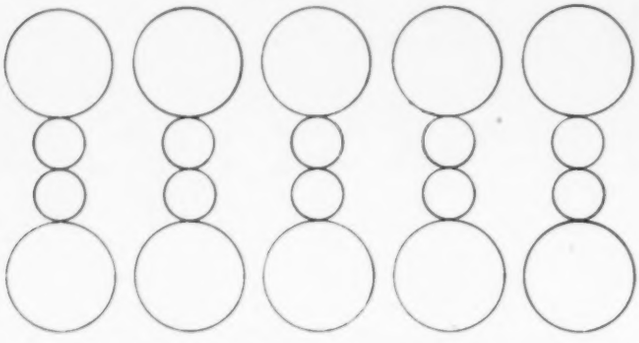


Figure 2 — Schematic shows roll arrangement in the five-stand tandem four-high cold reduction mill.

bearings. The rolls for each stand, two back-up and two work rolls, as assembled and ready for service in the mill weigh approximately 150 tons. The entire mill weighs over 3,000 tons.

The chucks, backup rolls, and work rolls unassembled and assembled can be seen in Figure 3 of the roll shop.

The electrical equipment required to operate the five-stand tandem mill has a total horsepower of 16,300. This is broken down as follows:

Stand	Hp
1	1500
2	3000
3	3500
4	3500
5	4000
Reel	800

These motors are serviced by generators having a capacity of 19,900 hp. The electric screwdowns are provided to control the tremendous pressures that are required to reduce the strip and are equipped with selsyn indicators.

High tensions are required between stands depending on the type of product to be rolled. Tensions vary from 5000 to 80,000 psi of strip cross section.

Entry guide boxes faced with hardwood boards and metal side guides align the strip entering the bite of the work rolls and provide tension in the strip when the box is clamped shut by an air cylinder.

The work rolls are driven by spindles from two-high pinion stands, which in turn are driven by a separate motor, or two motors coupled together, at each stand. The backup rolls turn from the friction created by the pressure against the work rolls.

Auxiliary equipment for the five-stand tandem mill

Figure 3 — Chucks, backup rolls, and work rolls both unassembled and assembled receive constant attention in the shop.

includes oil and solution tanks, pumps and filters; bearing lubrication for rolls and motors; roll change equipment; hydraulic hoist systems, etc. Solution or header sprays are attached to each stand and are divided into three sections, one at each edge and one at the center.

The rolling solution is an oil and water mixture which serves as a rolling lubricant and a roll coolant. Strip lubrication also greatly reduces the power required to produce a given decrease in gage. The solution, approximately 10 per cent oil in water, is recirculated from a 7500-gal tank by pumps which deliver the solution to the mill at approximately 4000 gpm and at a pressure of 100 to 200 psi. The amount of pressure used is variable and dependent upon the type of product rolled.

The exhaust system for the vapor produced during rolling has a capacity of 100,000 cfm. The vapors are drawn from the mill through a large subterranean tunnel and discharged through a scrubber.

Fire protection in the various oil cellars is furnished by a manually operated system. Proper warning systems are installed so that the crew is given time to vacate areas before the system is tripped.

The five-stand tandem mill is used almost exclusively for tin plate products because a four-stand tandem mill is available in the cold reduction department for the rolling of sheet products. Because the five-stand encompasses a greater range of reduction and speeds, this discussion will be confined to it. The width limitations at the five-stand tandem mill for tin plate products are from 24 to 37 in. wide. The final delivery gages range from 0.0070 to 0.0225 in. These are the extremes in both width and final gage. Because the process of cold reduction is relatively new on the West Coast, it may be of interest to describe how a tandem mill is actually set up, that is, how screw pressures and individual stand speeds are established to deliver a predetermined gage.

Tin plate steel is ordinarily a selected low-carbon

steel (maximum carbon about 0.10 per cent) to insure subsequent ductility for fabrication purposes in making containers. Assume that 0.0100 in. gage is to be rolled from a coil gaging 0.074 in. The first operations to be performed are the levelling of the rolls on each stand and setting the screw positions in order that the mill can be threaded properly. In levelling the stand, the rolls are brought down face-to-face and the solution is applied to the entry side of the work rolls. Then, the screws are jogged until solution appears between the rolls on the exit side. The screws are lowered until the rolls start to wipe, that is, the rolls are in contact to the extent that no solution can pass between the roll bite.

In order to have an absolutely level mill, equal amounts of solution must show at each barrel end. If there is a disparity in the amounts showing, the stand requires relevelling. The end of the work roll that shows the greater amount of solution is higher and more screw pressure is required on that side in order to have a level stand. This process is repeated for all five stands.

The preliminary screw pressure for the respective stands is determined as follows:

Starting at stand 1, about 8 in. of solution must show on the edges with the rest of the roll being dry. The amount of solution coming through the successive sets of work rolls must progressively decrease through the mill. At stand 5 the screw pressure is adjusted so that the work rolls are completely dry. By this method the sticking points of all stands have been determined with respect to screw pressure for threading. The next operation consists of checking and setting all guide boxes in exact widths and centers between the housings of the mill. No. 1 guide box is set at approximately the same width as the incoming strip. All other guide boxes in the mill are set one-half inch wider. In order to calculate the draft, the mill is accelerated to maximum voltage and the stands are preset to produce the aim gage.

In the example of rolling 0.0100-in. strip from an incoming strip gage of 0.074 in., it is known from experience that when the mill is set up, stand 1 reduces 0.074 in. starting gage to 0.060-in. gage. To attain the aim gage the reduction of the strip through the remaining stands No. 2 through No. 5 from 0.060 to 0.0100 in. must be determined. It is apparent that this reduction is in the ratio of 6 to 1. Therefore at full voltage the speed ratio between stands 1 and 5 must be in exact proportion to 6 to 1. Assuming the capacity of the unit to be 3500 fpm maximum, stand 5 is set as 3000 fpm. Therefore, stand 1 should be set at 500 fpm. The intermediate speeds are then set as follows: 2000 fpm on stand 4, as there is normally a fixed reduction from stands 4 to 5 of 33 per cent; stand 3 at approximately 1200 fpm, resulting in about a 40 per cent reduction at stand 4; and stand 2 at 750 fpm resulting in about a 33 per cent reduction. The total reduction on the 5-stand tandem mill averages 80 to 90 per cent for most tin plate.

The example of a finish gage of 0.0100 in. has been used because it reflects the typical mill setup. From this procedure, other finish gages are obtained by varying speeds and screw settings as required. The mill is preset for speed requirements and is decelerated to thread speed. Stand 1 is threaded and as the strip emerges, the stand is adjusted slightly for shape by coming up or down on the screw as required. The strip is then progressively threaded through the mill until it reaches the reel.

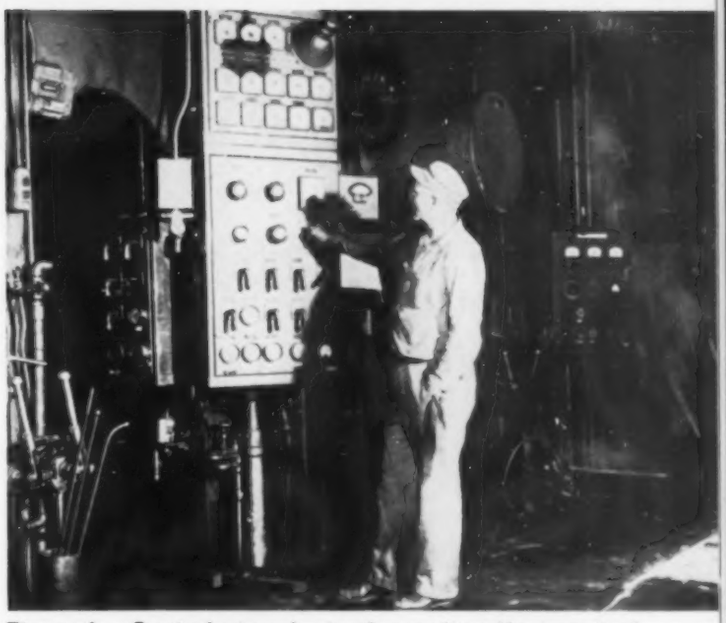


Figure 4 — Control at each stand permits adjustment of tension with the screw as the mill is accelerated.

The mill is at this point ready to be accelerated and each stand operator (Figure 4) adjusts the tension with the screw as the mill is accelerated. As 400 volts is approached, assuming of course that the mill is a 600 volt mill, the proper thickness should be attained. If this setup for some reason has been missed slightly on the heavy side, the speed of stand 5 is increased and at the same time the speed of stand 1 is retarded. In this manner the draft on stand 5 is increased, thereby producing a lighter gage and in retarding stand 1, less material flows into the mill; therefore, a lighter gage must result. The opposite procedure is followed should the initial setup have been light in gage.

Instruments are provided on the mill stands for tension control, but they do not provide the exact information the operator needs. For example, various shapes of the strip respond differently to tension and the tension must be varied to accommodate strip shape. A full strip has considerably more edge tension than does a flat strip; therefore, it cannot be pulled between mills and conversely, a flat strip can be pulled harder. These variable tension-shape conditions across the width of the sheet cannot be measured by the available instruments, therefore, a one-in. maple board is used to tap the moving strip to test and adjust it until the proper degree of tension is obtained. This amount of tension is thereafter maintained using the tension control instruments. During subsequent rolling of coils, as the mill warms up and screw pressure varies because of the inherent pickup of heat and crown of the rolls, changes in sprays or drafts are required to assure a constant shape without strip breaks.

Now that the mill is set up and ready to roll, perhaps it will be of interest to comment in some detail as to just what happens in the cold reduction of steel and what auxiliary services are required.

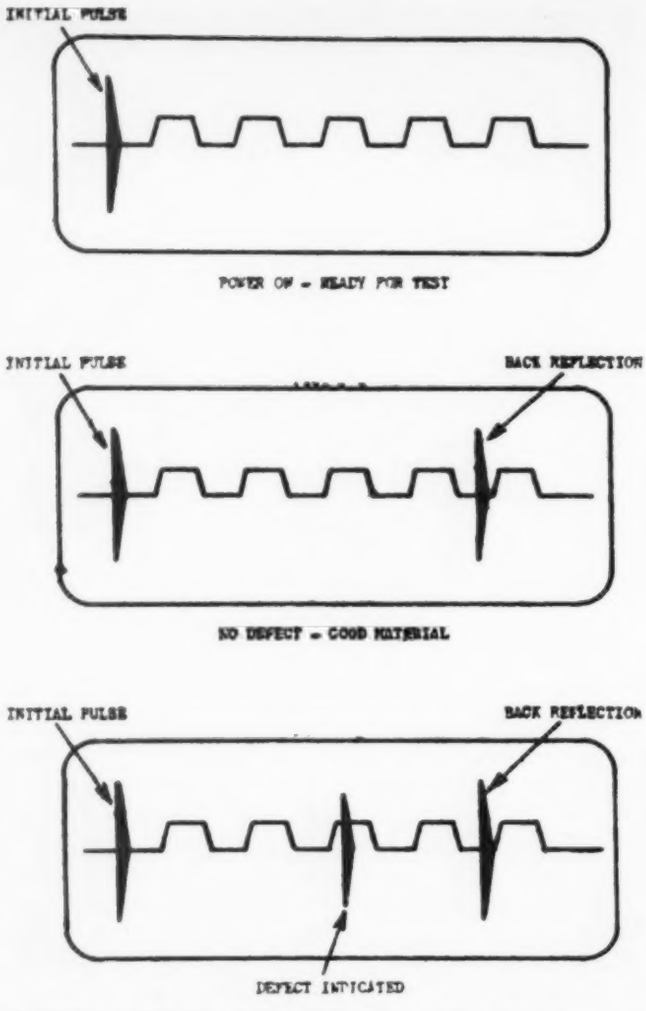


Figure 5 — Typical ultrasonic testing results as seen on the screen of the gage shown on top: power on (ready for test), good material in center, and defective material on bottom.

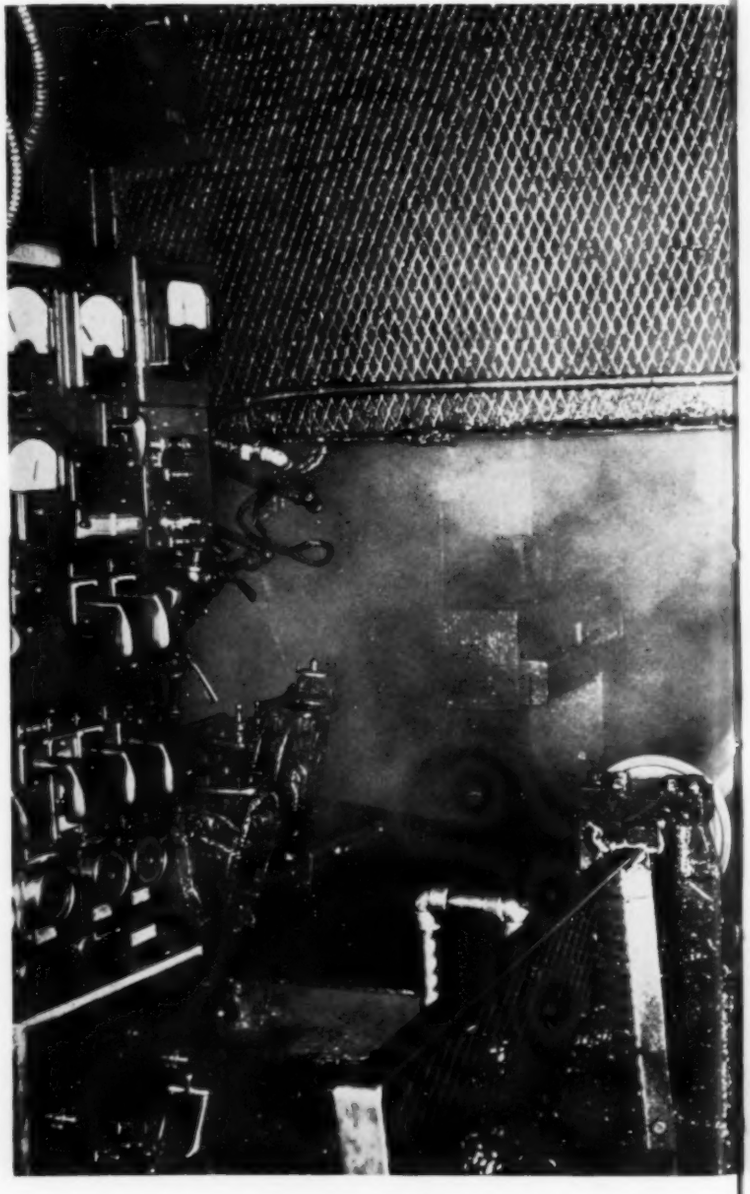
The combination of roll pressure and tension is necessary and both contribute to cause the reduction in steel thickness in each stand: roll pressure alone cannot cause the reduction because, for the widths indicated here, pinching and poor shape would result. Tension alone could not effect the reduction because the strip would break during the elongations required.

The strip entering the roll bite of a stand is moving at a slower speed than the surface of the rolls, but its speed increases within the bite and finally issues from the roll at approximately the same speed as the roll surface. This difference in speed over a part of the roll bite between the strip and the roll surface occurs under high pressure. The movement between the strip and roll is made possible by reducing the friction between them with lubrication. If too little lubrication is provided, torn surface of the strip will occur. If too much lubrication is furnished, the rolls will slip and proper reduction cannot be made.

Cold reduction is normally carried to at least one-half the original strip thickness, and twice the original strip length, in order to avoid bad grain structure during subsequent annealing. A maximum reduction to about one-tenth the original thickness and ten times the original length is possible before the steel becomes so hard and brittle that further cold work is uneconomical.

Cast iron work rolls are commonly used in the first two stands of a five-stand tandem mill and forged steel work rolls in the last three stands. The softer iron rolls are used in the entry stands where the strip has been only partially work hardened. In the delivery stands where the strip approaches the full hard stage, the hardness of the rolls is of prime importance and the finished surfaces on the rolls must be made progressively smoother. The crown of the rolls is varied according to the type and width of the product rolled. There is no way to establish a crowning practice that would be universally applicable to all mills, as the crowning of the rolls depends on several variable factors such as the width of the mill, type and hardness of the product, and shape of hot mill strip. Although a crown is ground into the work rolls for each stand, the final or roll crown is obtained after a short period of rolling by controlling the temperature of the roll. The rolls of each stand assume a shape that conforms to the shape of the incoming strip. By throttling or controlling the amount

Figure 6 — Thickness gage at exit end of five-stand tandem mill.



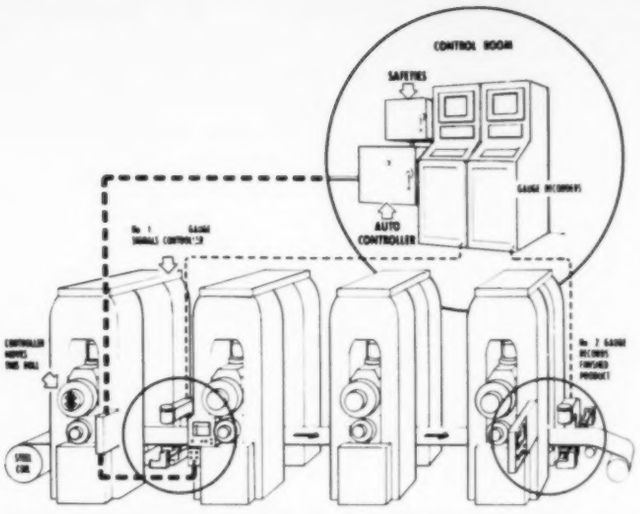


Figure 7 — Gages automatically control thickness of strip in cold roll mills.

of solution applied to either the edge or the center, a certain amount of general control of the roll shape or crown is possible.

Considerable work has been done in the development of various types of rolling oils in order to improve surface characteristics and overcome some shape difficulties that have been prevalent in past years. Substantial progress has been made in this endeavor and it is confidently expected that further improvements will result from continued research and experimental work.

From time to time a backup roll in one of the stands may develop a crack or contain some other internal defect not visible on the surface. When pressure is applied to this roll during the rolling process, a cyclic deflection of the roll occurs at the defective area, which results in non-uniform strip gage or shape. To detect the presence of these internal flaws, an ultrasonic gage is used. By placing the searching unit of the gage against the roll, ultrasonic vibrations are emitted and pass through the roll. When the vibrations are interrupted by an internal crack, pocket, or inclusion, or by the far side of the roll, they are reflected back to the searching unit. The reflected waves are picked up by a quartz crystal in the searching unit and transmitted to an oscilloscope. An analysis of the wave pattern displayed on the oscilloscope will determine the presence and location of a defect. By moving the searching unit to various positions on the roll, the extent of the internal flaw can be established.

Examples of this ultrasonic testing technique, as seen on the screen of the gage, are illustrated in Figure 5.

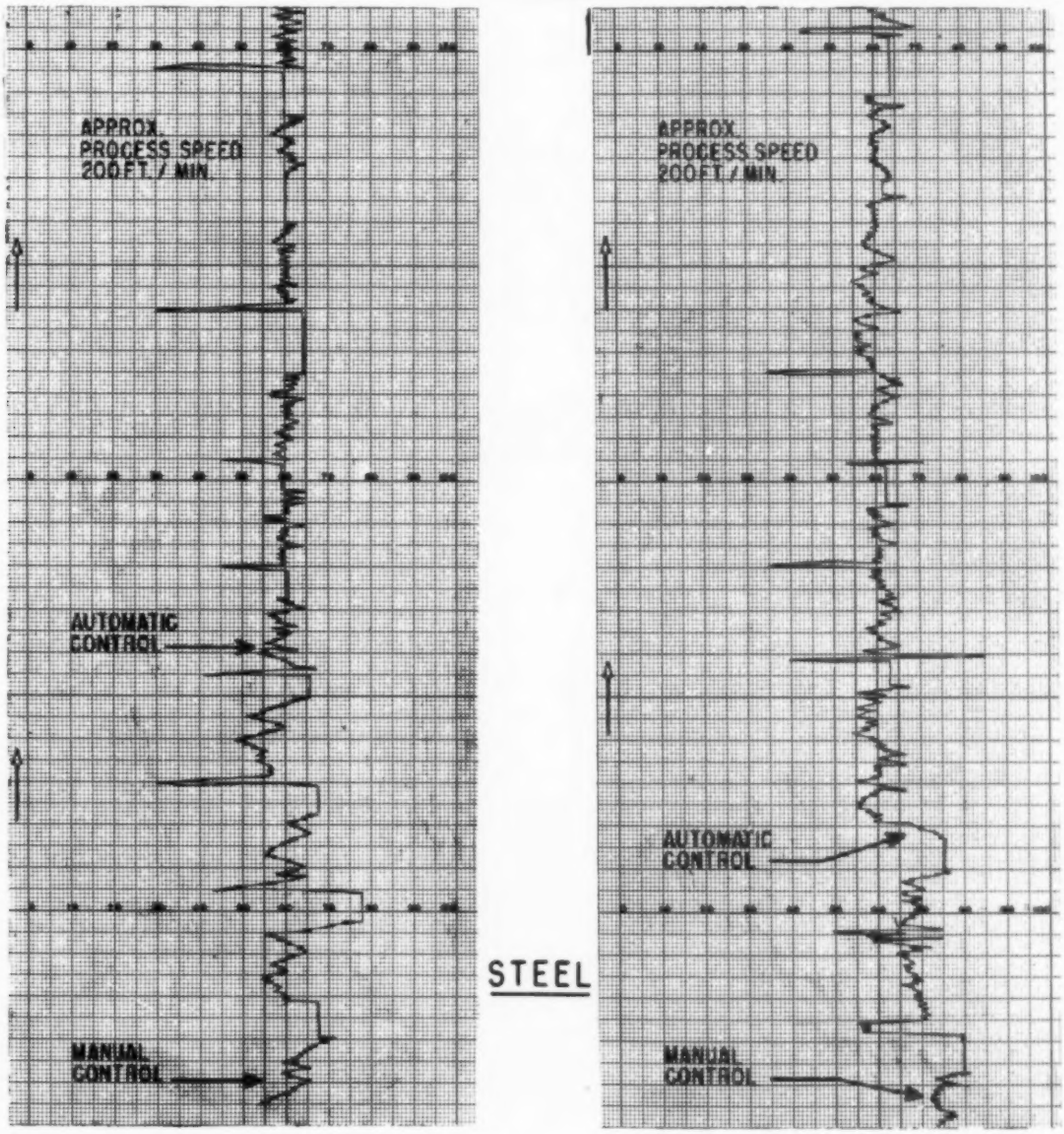


Figure 8 — Chart shows effectiveness of thickness gage control in stand one.

The sound waves appear as vertical indications along a line of square wave markers. The markers represent units of distance. The "inital pulse" indicates the testing surface. The "back reflection" indicates the reflecting surface. Indications between these two references show discontinuities in the material, and their positions along the markers accurately locate the discontinuities with respect to the surfaces.

Some surface roughness of steel strip is desirable, and the required degree of roughness varies by type of tin plate. This surface roughness is imparted to the strip by the roll surface during the temper rolling operation, and is controlled by the coarseness of grit used in grinding and shot blasting the rolls. An instrument used for measuring surface roughness of the rolls and strip in the profilometer, which consists of a tracer and an indicator. As the point of the tracer is moved over the surface of the roll or strip surface to be measured, its vertical motions due to surface irregularities are converted into small fluctuating voltages which are shown on the indicator. The use of this instrument permits the establishment of standards for surface roughness. These are but a few of the many improvements that are being made in cold reduction operations at Pittsburg Works.

One of the most outstanding developments of recent years has been the installation of a continuous noncontact type strip thickness control system at the five-stand tandem mill at Pittsburg Works. In this type of gage, the steel strip to be gaged passes between a radioactive isotope material radiation source and a radiation detector unit. Some of the radiation is absorbed by the strip, the rate of absorption being proportional to the weight per unit area of the strip. The radiation which passes through the material enters an ionization chamber. A high voltage placed across the ionization chamber causes an ionization current to flow when radiation is present. By means of an electrical circuit and pen recorder, the resultant voltage is then recorded in terms of strip thickness.

The automatic control system consists of two sections, a coarse system operating on the screwdowns of stand 1, and a vernier system regulating the speed of stand 5 to adjust tension between stands 4 and 5. The coarse system reduces large thickness variations in the incoming strip, and remaining small thickness variations are further reduced by the vernier system, which operates on the drive system of stand 5. Thickness of the finished strip is controlled over a limited range by varying the speed of stand 5, thereby varying the tension between stands 4 and 5.

A thickness gage is shown in Figure 6 at the exit end of the five-stand tandem mill. As this gage measures from a true end absolute value rather than from a preset aim gage, a recording is obtained of the actual strip thickness delivered from the mill.

An installation of these thickness gages, comparable with that on the Pittsburg Works cold reduction mill is shown in Figure 7, with a strip thickness recording and controlling gage between stands 1 and 2 and a thickness recording gage at the exit end of the last stand.

The effectiveness of the thickness gage in controlling stand 1 is shown in Figure 8. In each of the lower portions of the recording charts, the strip thickness from stand 1 was manually controlled. In the upper portion of the charts the decrease in thickness variation through automatic gage control is evident.

All of these modern techniques have resulted in significant quality improvement in cold reduced sheet and tin mill products. Thickness and surface are consistently good, and assist in making many fabricating operations more economical and productive. As fabricating speeds increase and product uses become more severe, these more exacting customer requirements will be matched by continuous emphasis on quality control.

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BUFFALO SECTION

Tuesday, June 4, 1957
Sixth Annual Golf Meet
Cherry Hills Country Club
Ridgeway, Ontario, Canada

CHICAGO SECTION

Tuesday, June 4, 1957
Golf Party
Gary Country Club
Gary, Ind.

DETROIT SECTION

Saturday, June 15, 1957—Cocktails 6:30 P.M., Dinner 7:30 P.M., Dance 9:30 P.M.

Summer Party—Dinner and Dance
Birmingham Country Club
Birmingham, Mich.

PITTSBURGH SECTION

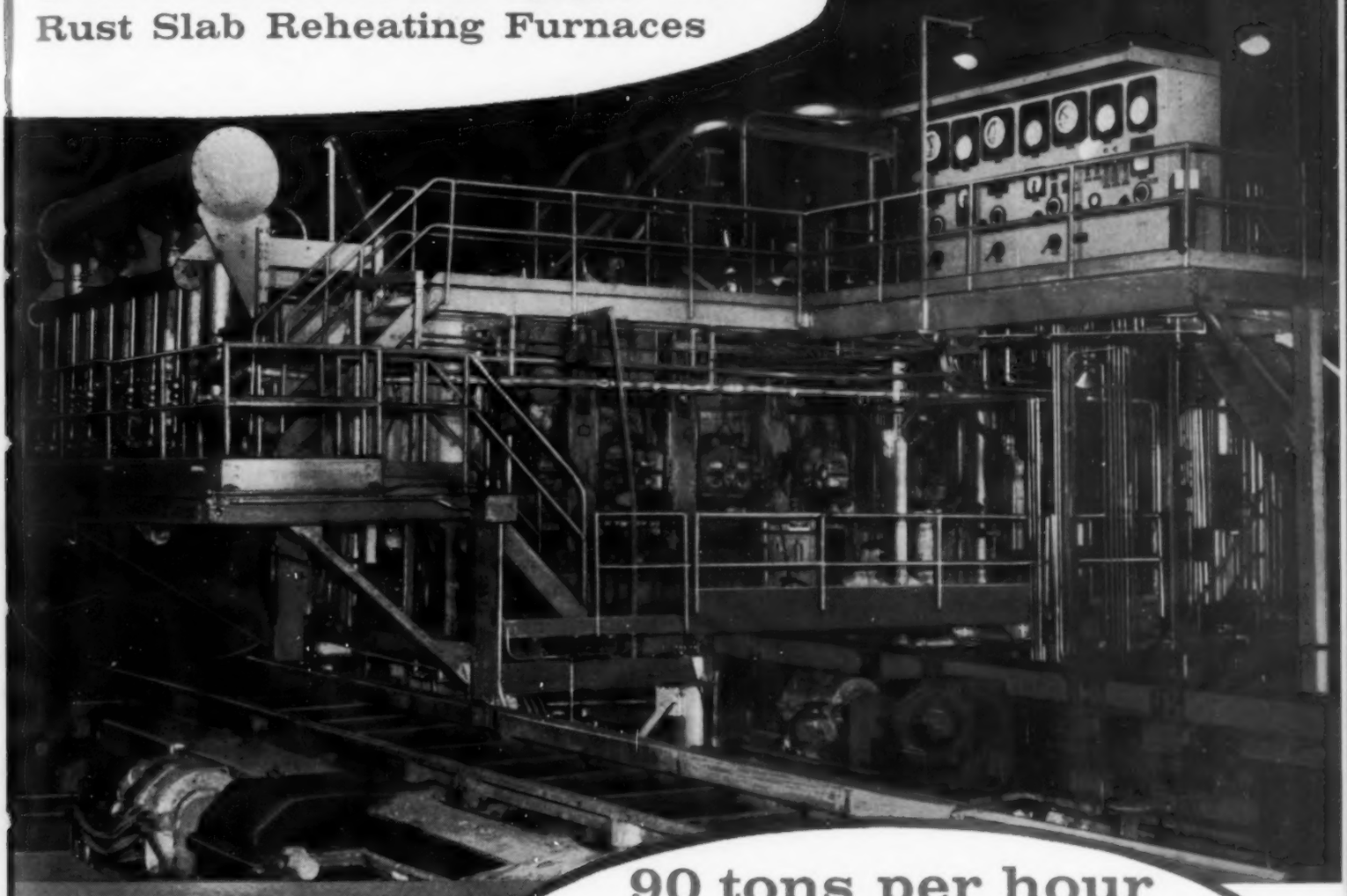
Monday, June 24, 1957
Golf Party
South Hills Country Club,
Pittsburgh, Pa.

YOUNGSTOWN SECTION

Wednesday, June 19, 1957
Golf Party
Tippecanoe Country Club
Youngstown, Ohio

Detroit Steel Corporation's modern plant at Portsmouth, Ohio equipped with

Rust Slab Reheating Furnaces



90 tons per hour

. . . the slab heating capacity of this triple-fired, end-charged, end-discharged, Continuous Reheating Furnace. Metallic Recuperator aids fuel economy.

THE WHOLE JOB IS ONE JOB WITH A "RUST PACKAGE CONTRACT"

One contract covers everything, from original idea to start-up. One responsibility for design, manufacture, erection and initial operation. One overhead and profit (with substantial savings to you) on all phases of the work, including wiring and piping.

Two of these Rust Furnaces, at Detroit Steel Corporation's Portsmouth Division, heat slabs to rolling temperature at a total rate of about 180 tons of cold steel per hour. Furnace temperature ranges from 1650°F. at the entry end to about 2400°F. at the discharge end.

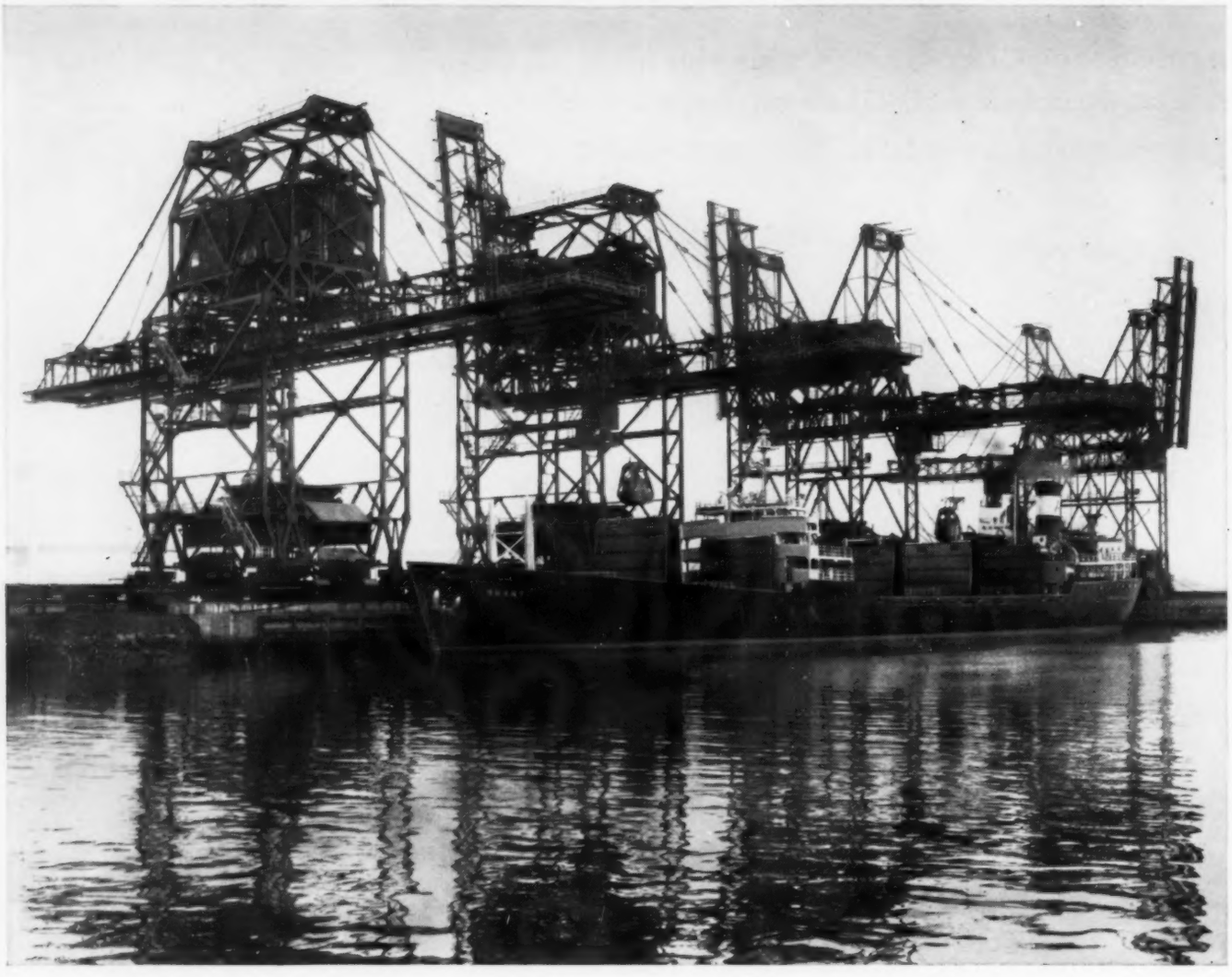
Temperature and combustion control is completely automatic, with easy operation from a central panel board. Flexibility is achieved by simply changing the fuel firing rate in the heating zone. Metallic Recuperators preheat the air for combustion, resulting in high tonnage output with minimum fuel consumption.

Rust also builds all other types of metallurgical furnaces. Consult us about your requirements. Ask for catalog.

Rust Furnace Company

Pioneers in Furnace Design

Rust Building • Pittsburgh 22, Pa.



Dravo builds second 1800 ton per hour unloader for PRR

In July 1955, Dravo finished an 1800 ton per hour man trolley unloader for Pennsylvania Railroad's giant ore pier at Greenwich Point, Philadelphia, operated by The Pennsylvania Tidewater Dock Company. Its trouble-free operation and tonnage handling capacity led to the ordering of a second Dravo-built ore unloader within six months. This unloader began operation 370 days after it was ordered.

These heavy duty machines use an adjustable voltage system for maximum horsepower output and fast handling cycles. The average cycle time is 45 seconds, but Pennsylvania Tidewater's skilled operators frequently lower that time to 36 seconds. A 20,000-ton ore ship is unloaded at the pier in less than seven hours. Two such ships can now be unloaded simultaneously.

Dravo heavy materials handling equipment is at work in steel mills, power plants and other materials transfer points. Each piece of equipment is designed to provide fast, smooth operation with maximum efficiency and low operating cost.

For information about Dravo's complete line of trolleys, bridges, towers and other related equipment, write for Bulletin #225. Better still, let us arrange for your visit to actual installations. Simply call us at Pittsburgh, Spalding 1-1200, or write DRAVO CORPORATION, PITTSBURGH 25, PENNSYLVANIA.

DRAVO

CORPORATION

Blast furnace blowers • boiler and power plants • bridge sub-structures • cab conditioners • docks and unloaders • dredging • fabricated piping foundations • gantry and floating cranes • gas and oil pumping stations • locks and dams • ore and coal bridges • process equipment • pumphouses and intakes • river sand and gravel • sintering plants • slopes, shafts, tunnels • space heaters • steel grating • towboats, barges, river transportation

Figure 1—Panels are arranged to give maximum convenience to the operator.

An Automatic Blast Furnace Charging Control System

▲ PROVEN components and thorough design feature the new automatic blast furnace charging control developed by Arthur G. McKee & Co., Cleveland, Ohio, and Cutler-Hammer, Inc., Milwaukee, Wis., for the third blast furnace now under construction for the Fairless plant of the United States Steel Corp. The new system does not essentially change the basic functions of the existing control processes; it does, however, incorporate a number of substantial improvements over existing systems and these include more simplified operation of the panel board, and an operational check system which automatically isolates and points out failures in the sequence operations of blast furnace charging.

The system consists essentially of three panel boards which include a scale car operator's panel, which is a small console at the edge of the stock house platform with ready access to the scale car operator. Behind this is a separate indicating, manual and transfer panel. A control panel is also located in the hoist house. Each of these panel boards contain hundreds of circuits and switches, keyed to individual lights, which automatically control the processes from the time coke is taken out of bins and from the time when iron ore and limestone are dumped into the skip, until the material is dumped into the blast furnaces. The system measures the ingredients, controls conveying the material on the skip hoist and dumping of the skip, controls the operation of the large and the small bell, and controls rotation of the distributor. Safety checks and interlocks prevent any step from being taken except when ready and safe thus preventing possible accidents. Control also can be set to add water in correct amounts if top temperature becomes too high. The basic components are designed for trouble-free operation with units familiar to steel mill maintenance men, thus simplifying maintenance procedures. A fault panel helps maintenance men to quickly determine where troubles are located reducing possible downtime. Mounted on the panel board are a number of individual lights using a different color code which tells the operators exactly what is going on at all times.

The scale car operator's panel, located in the stock house, includes those items needed by the scale car operator for normal operation of the furnace. All panels are sectionalized to clearly set apart the groups of devices according to the function which they perform. The scale car operator's panel has four sections in one are all the devices for the coke system; in the second is included a start push button with all indicating lights needed by the operator when operating on automatic cycle; the third section includes all the devices which the operator uses to alter the preselected charging program, and the fourth section is a record section for instrument sheets and records.

The indicating, manual and transfer panel, located in the stock house behind the scale car panel has six sections. One section includes alarm indicators, total load cycle counter, and electric clock. Below this section is the indicating section for the coke system. On the right of these two sections is the program indication section, the manual operating section, the manual-automatic transfer section, and the regulator-indicating instrument section.

The program indication section is similar to a panel in the hoist house where the entire charging program is set up by means of selector switches. Control is so arranged that a charging program of up to 18 loads can be selected and the large bell can be set to dump at any number of points in the program. This panel has three vertical rows of rectangular indicating lights with 18 lights in each row which show the

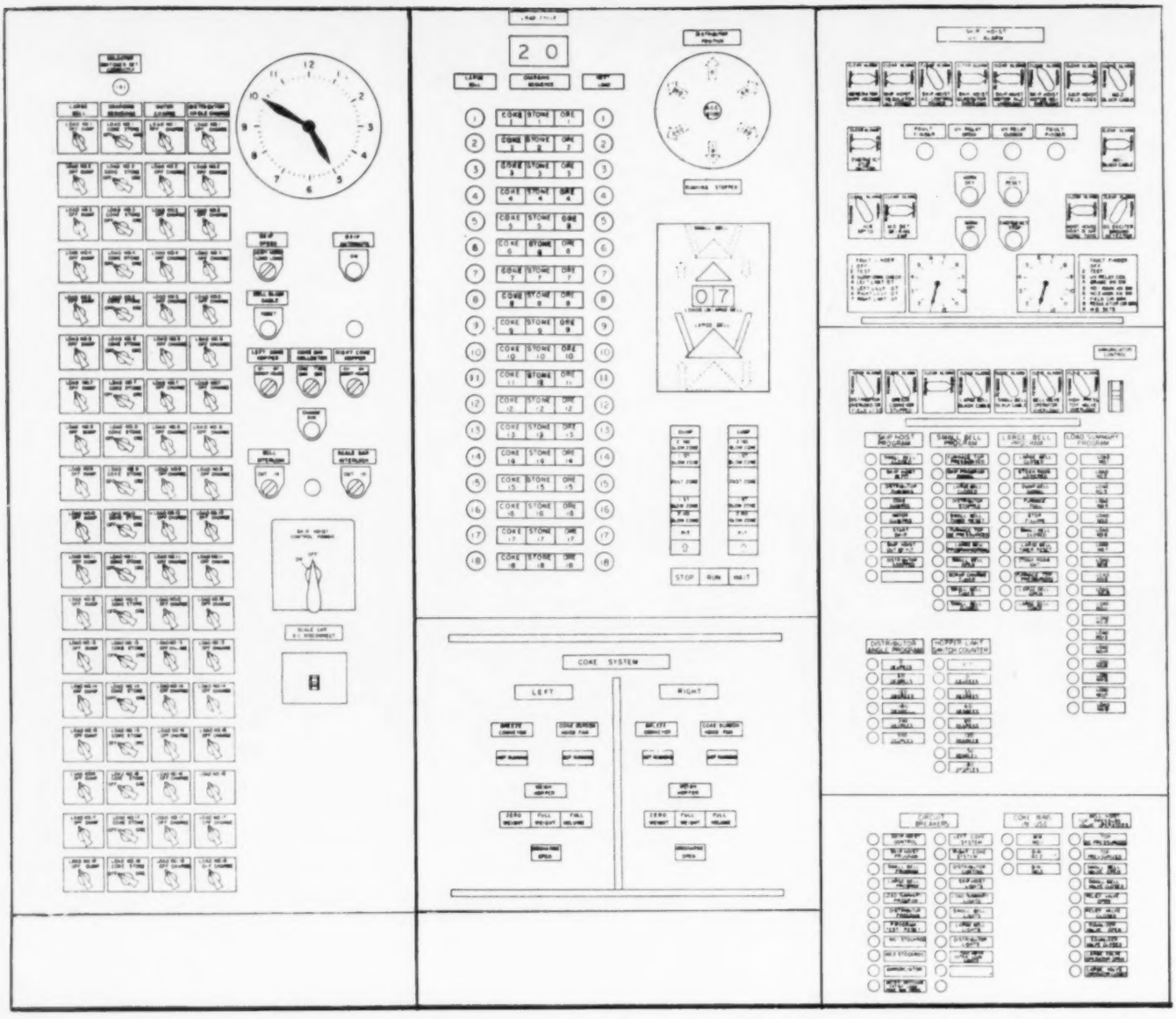


Figure 2—Portion of panel in hoist house shows from left to right—program selector unit, program indication unit, and hoist house annunciator unit.

selected charging program of ore, coke, and stone. Different colored lights are used for each material helping the operator to more easily follow the program. Another vertical row of lights on the left side of this panel has those lights lit which indicate the points in the program at which the large bell will dump. On the other side is another row of lights which tell the operator which load is to be charged next, and only one light is lit at a time in this row. This panel also indicates the operation of the skip hoist, large and small bells, and distributor. Two rows of lights show the movement of the two skip cars and clearly indicate their location at all times. If the skip hoist stops with the skip cars in some intermediate position, the relative positions of the cars is indicated and an arrow shows which car was traveling toward the top at the time the skip hoist stopped. Additional lights indicate whether the skip hoist is stopped, running or waiting to be started. A graphic representation of the large and small bells shows when the bells are fully open or fully closed or are in the process of opening or closing. Two numeral indicating lights count the number of loads on the large bell, and these lights reset to zero every time the large bell dumps. Every load deposited on the large bell is counted whether it is part of the preselected program or an extra load added by the scale car operator. The distributor position is depicted by arrows arranged in a circle at 60-degree intervals. Only the arrow corresponding to the distributor position will be lit. An additional light at the center of the circle will be lit when the distributor is accurately stopped.

On the right of this panel, combination recorder-indicators give continuous information and a record of the stockline and of the furnace top temperature. The top pressure in the furnace is also indicated in this section.

The control panels located in the hoist house include from left to right, the program selection panel, the program indication panel (this is essentially a duplicate of that in the stock house), an annunciator panel. In addition, the motor and solenoid relays and contactors and motor-operated program switches are included in this unit. The program selection panel is used to set up the

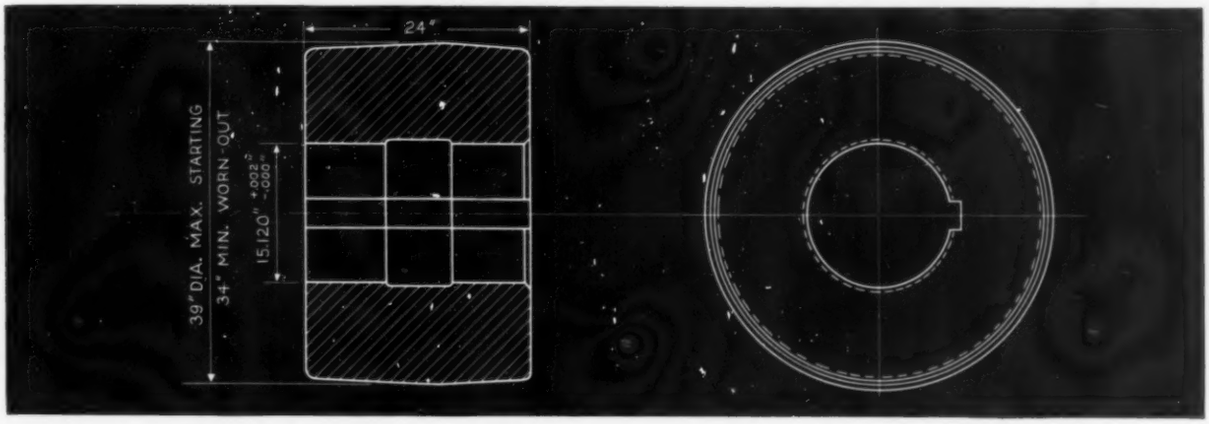
TIPS FROM A ROLL MAKER'S NOTEBOOK

MACKINTOSH-HEMPHILL DIVISION, E. W. BLISS COMPANY, Pittsburgh 3, Pennsylvania

Cast mill rolls • Johnston cindor pots • rotary tube straighteners • end-thrust bearings • heavy-duty lathes • steel and special alloy castings

THE SECRET OF GOOD TUBE MILL RINGS:

Put the extra metal where it does the least harm



Any roll ring cast with a cored hole creates special problems. Tube mill piercing rolls are no exception.

General foundry practice has been to allow sufficient stock on both the outside diameter and bore to permit "giving a little and taking a little" to "true" the finished O. D. with the I. D. when machining. Mack-Hemp foundrymen have modified this practice by keeping the outside stock at a minimum and increasing the stock in the bore. This extra stock in the bore provides an ample margin for "truing up" the two diameters during finishing, with only a bare minimum of metal removed from the O. D.

The roll user benefits in two ways—better rings at a lower price. In the first place, with roll rings priced as they are, on a "cent-per-pound-on-rough-weight" basis, he saves money. This is because extra metal near the center of the roll weighs far less than the same thickness at the roll surface. For instance, every ¼" of oversize on the O. D. of a 39" diameter, 24" long ring adds roughly 110 pounds of metal. On the other hand, ¼" extra stock on the 15" bore of the same ring adds only 40 pounds.

The segregation problem—Even more important, however, is the improvement in the depth of sound metal below the surface of the cast roll which is gained by casting to minimum tolerances on the O. D. and maximum on the I. D. Mack-Hemp tube mill rolls are noted for their freedom from the "segregated streaks" which lead to scrapping before worn-out diameter. Since these flaws usually occur at a fairly regular depth below the outside surface of a cast roll, the closer the O. D. as-cast diameter is to the finished diameter, the deeper this zone of segregation.

The relation of "bite" to hardness and wea: —A very important requisite of a piercing mill roll is good "bite" to eliminate slippage. Ideally, this should be achieved without sacrificing too much wear resistance. Fortunately, bite and wear resistance are not always in direct proportion to hardness. Both these qualities can be combined—at least to a degree—in the same roll. For example, a roll of one alloy type may slip more than a harder roll of another type. Today, higher speed mills have stepped up the demand for these better, harder rolls.

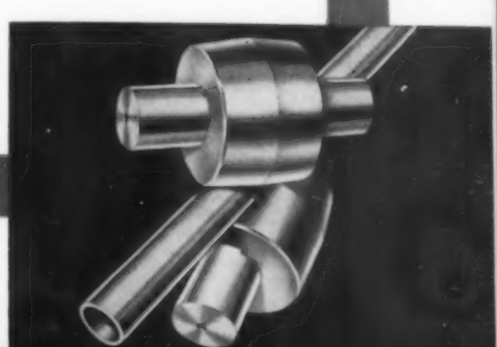
Mack-Hemp's broad experience with the many tube mills now in operation can be of real help to any tube mill operator with a roll problem. And it's the same story no matter what your type of mill. For help with any problem of roll use, call on Mackintosh-Hemphill Division, E. W. Bliss Company, 901 Bingham Street, Pittsburgh 3, Pennsylvania.

MACKINTOSH-HEMPHILL

You get more tonnage from the rolls with the Striped Red Wabblers

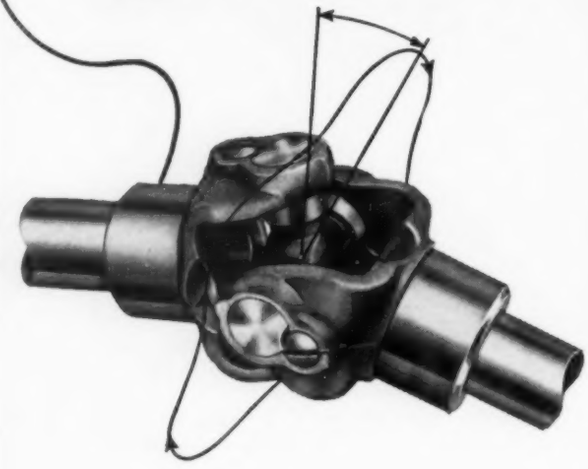
Division of E. W. BLISS COMPANY

Presses, Rolling Mills, Special Machinery



THIS ACTION MAY HAVE A

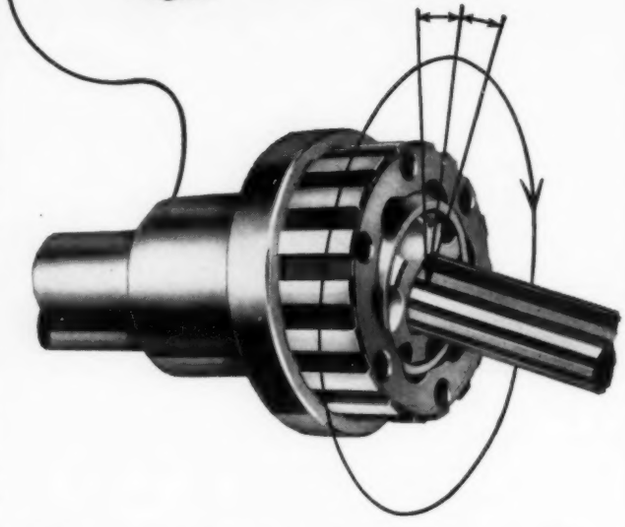
LOWER PRICE



Old-fashioned pin or slipper-type joints speed up, slow down twice during one revolution. This delivers rough "rock and roll" torque which results in greater vibration and wear. They must employ clumsy additional mechanisms to compensate for their unbalanced action at extreme angles.*

THIS ACTION ALWAYS HAS A

LOWER COST



Rzeppa Joints *always* transmit smooth "full power" torque at angles as much as 35°! Ball bearings—located in a plane bisecting the angle between driving and driven members—deliver smooth rotation, eliminating wear and vibration. Constant velocity means longer joint and shaft life, too.*

57A

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CONSTANT VELOCITY UNIVERSAL JOINTS

The Gear Grinding Machine Company

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MANUFACTURERS OF: FULLY AUTOMATIC GEAR GRINDING MACHINES
DETROIT SCREWMATIC 750 SINGLE SPINDLE SCREW MACHINES

*HOW RZEPPA'S CONSTANT VELOCITY SAVES YOU MONEY. If a universal joint operates with less friction it wears longer; if it has a higher capacity it can produce more. Through the principle of constant velocity—shown above—Rzeppa delivers these cost-savings that are impossible with designs of lower price.

Send us a dimensional sketch along with peak horsepower, operating angles and R.P.Ms. Our engineers will assist in making a proper joint recommendation. WRITE FOR LATEST BROCHURE.

charging cycles of ore, coke and stone as well as the loads on which water is to be added. Switches are also included that enable the operator to select the points in the program at which the large bell is to dump, and also the points at which the distributor angle is to be changed. These two operations can be selected separately and are independent of each other giving flexibility in the selection of the charging cycle.

The annunciator panel has memory type fault finders which monitor protective devices which will operate momentarily on the fault and then reset. Tap switch type fault finders will check the device which will open a circuit and remain open until reset. The balance of the panel has neon indicating lights to indicate positions of all motor operated program switches and thus give program progression. The lights also serve as individual check points helping to locate the exact point of trouble if operation is interrupted. All motor-operated program switches have 18 points and 24 separate circuits. Windows in the cover permit quick inspection of the double-break, cam-operated contacts.

Control panels are sectionalized for easy maintenance as are the control circuits. All control circuits are 110 volts alternating current. Color coding is used on all wiring to identify polarities and general circuit voltages.

Door Jambs Made of Suspended Basic Refractory

▲ IN an open hearth furnace the failure of the front walls, especially the door jambs is exasperating, and this is especially true if the failure occurs during a campaign.

Frequently, the failure is caused by the more rapid erosion of the lower refractories. When this erosion is of sufficient depth the upper unsupported walls will collapse, and many times necessitate an entire rebuild. To solve this problem, the Geo. P. Reintjes Co., began devoting their efforts to the design of a suspended front wall.

Due to the many problems involved, it was decided to utilize externally supported metal encased basic refractory wall and arch constructions similar to those which have proved so serviceable and economical in the open hearth applications.

By a slight modification of these tiles and similar designed castings, suspended basic refractory door jambs are formed. So that each tile can be individually supported from the rear, the corners are rounded. This rounding also protects the jambs from the charge bucket. The castings are supported from the vertical leg of formed angles. These angles in turn are supported from the vertical buckstays.

To permit the tiles to be more readily demounted every other course of tile is inverted and hung from the same pintle that supports the tile below.

Near the floor plate where erosion is usually the greatest, the present method of building solid walls should be used. The suspended portion of the walls above will remain intact while the lower portion is being repaired. Where necessary the upper portion of the suspended walls could be repaired at the end of a campaign.

Where erosion is not a severe problem, then the walls can be entirely suspended from the foreplate to the roof.

Figure 1 — Suspending the door jambs has reduced failures during furnace campaigns.

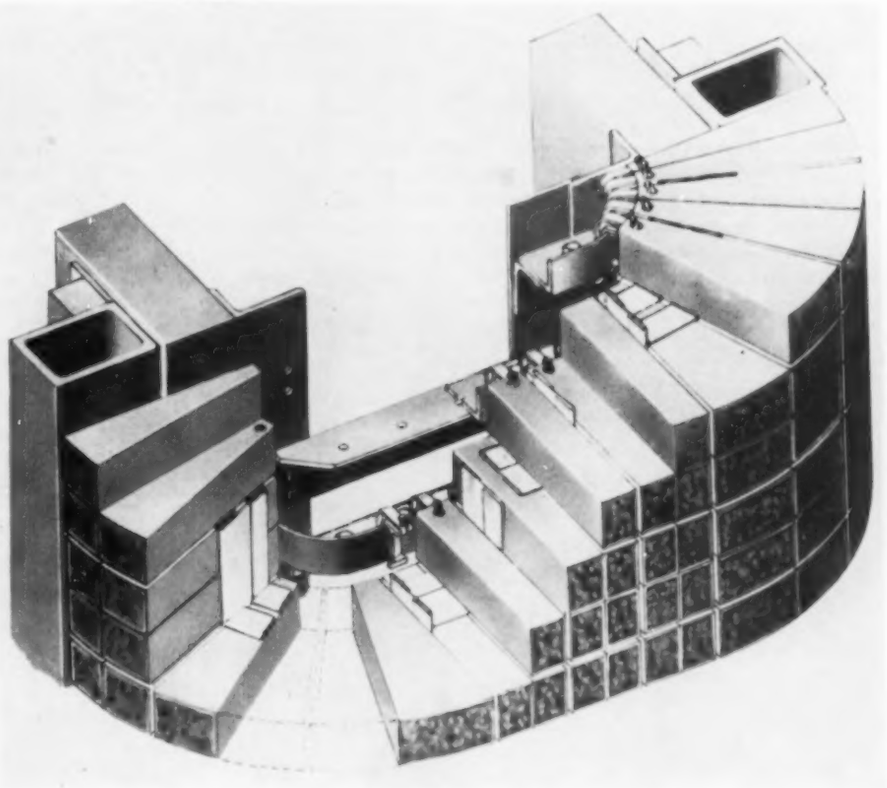


Figure 1 — A three dimensional model was used to preplan the design and setup of the new plant.

RELIANCE SETS PATTERN FOR FUTURE GROWTH

▲ A new plant addition to the Ashtabula division of the Reliance Electric and Engineering Co., which began full production early this year, represents a milestone in efficient manufacturing of electric motors. Plant will build motors from 1 to 40 hp, and was designed with the philosophy of building parts for stock rather than specific order, and then assembling the parts to meet customer requirements. Thus, flexibility has been built into the plant at the same time including the most modern techniques of automatic production, and Reliance will be better able to handle the overall corporate shipments which have more than quadrupled over the past ten years, from $14,000,000 in 1945 to more than $64,000,000 in 1956.

In addition, a new general office building was recently completed in Euclid, Ohio, to house the general sales offices, purchasing, marketing, accounting and other administrative functions.

As part of its growth picture, Reliance this year introduced four new products and has a full-time research group working on the development of new products in new fields.

FEATURES OF ASHTABULA PLANT NO. 3

The new plant no. 3 at Ashtabula, Ohio, encompasses an area of 90,000 sq ft and was designed as an automated motor plant expansion of the original Ashtabula facility. A 10,000 sq ft section was subsequently added for welding and stores.

The use of a model, at an exact scale of ¼ in. to the foot reduced the time necessary to get the plant in

Figure 2 (left) — One of the very unusual items of equipment is an automatic transfer machine on which three diameters of motor frames can be machined. When frame sizes are changed, the operator simply changes the stroke of the shuttle. Color-coded dogs, or spacers, are used to set up the transfer machine. The colors indicate frame size. Unit can produce about one frame per minute. Setup time for changing from one frame model to another runs from one to nine hours. Figure 3 (right) — The new general offices of the Reliance Electric and Engineering Co. were designed so that the facilities may be doubled in the future.

SHELL FORM
CORE FORM
Substation Transformer
100,000 KVA, 3 Phase
With load tap changing equipment. High Voltage: 330,000 Grd Y volts with ±10% regulation in 32 steps of ⅝%. Low Voltage: 14,400Δ volts.
Generating Station Transformer
48,000 KVA, 3 Phase
High Voltage: 115,000 Grd Y volts. Low Voltage: 13,200Δ volts.

Pennsylvania builds *Both* types of Power Transformers for Generating Station and Substation Service

With wide experience in both shell form and core form design, Pennsylvania Transformer engineers are able to provide the transformer that is best suited to every application. Full consideration is given to size and weight, ease of installation, impedance, resistance to short circuit stresses, insulation strength, method of cooling, and other characteristics which result in definite advantages in a given kva and voltage for one design or the other. **Core form or shell form?** Why not let the answer for your next transformer be based on Pennsylvania's proved principles of power transformer design? Pennsylvania Transformer Division, McGraw-Edison Company, Canonsburg, Pa.

PENNSYLVANIA TRANSFORMERS pt

PENNSYLVANIA POWER TRANSFORMERS

How many costs are hidden in bundled stainless scrap?

SOME that you know of — the cost of handling, the space it requires, and the melting loss you've already figured on.

But it's the unknowns — like the possible contamination of a heat — that can really hurt — that too often make this source of alloy metal a poor bargain at best.

Contact us today — find out why so many producers find it actually pays to buy Alloymet nickel base pig and shot* at a premium of approximately 5% over the cost of nickel scrap.

** Alloymet available in a complete range of nickel chrome, nickel iron and nickel copper analyses.*

ALLOY METAL PRODUCTS, Inc.
PHONE 6-2561 • TELETYPE DV 588
(FORMERLY A DIVISION OF **ALTER COMPANY**)
ROCKINGHAM ROAD
DAVENPORT, IOWA

World's largest producer of secondary nickel alloys of certified analysis

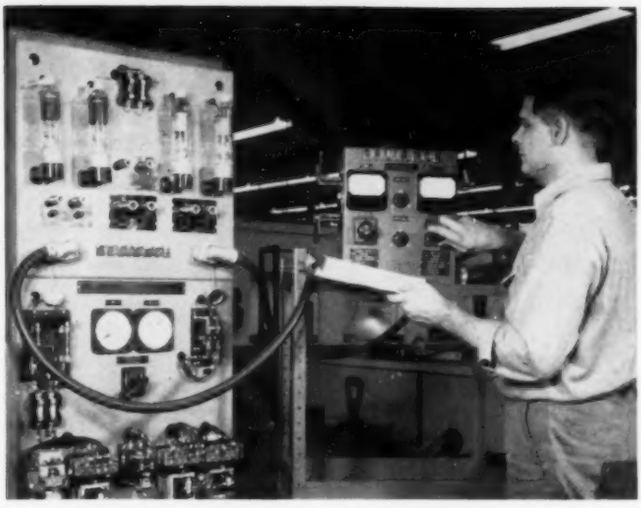


Figure 4 (left) — Maintenance has been simplified on this unit. Figure 5 (right) — Units are available for many types of mountings to fit various applications.

operation. Only one layout change has been necessary, compared with the many changes required in some of the older plants built without this technique.

As each department was laid out with the three dimensional models, foremen were called in, along with the actual men who were to operate the machines, and the entire setup discussed by those men who would have to use the equipment. After all were in agreement, top management came in and the final design was approved.

ADMINISTRATIVE OFFICES

A new $1,250,000, three-story air-conditioned office building now centrally houses the sales and general administrative offices of Reliance Electric and Engineering Co. The building, located at 24701 Euclid Avenue in Euclid, an eastern suburb of Cleveland, Ohio, is the hub of a 69-acre campus-type site serving as headquarters for the rapidly expanding manufacturer of electric motors, motor control and variable-speed drives and drive systems for industry.

The new 65,000 sq-ft building was nine months in erection and preparation for occupancy by the 300 Reliance office personnel who moved in the first of this year.

NEW PRODUCTS

A new dual-circuit, variable-speed electronic mill regulator for application in high-performance, continuous-process mills has been developed. The new regulator, designated the "VSMR," is designed for drive control on machines requiring the performance capable only through the use of electronic control coupled with the utmost continuity of performance, such as are common to the paper, rubber, glass and nonferrous metals industries.

Basically, the new VSMR operates on two sets of output thyratron tubes operating in parallel. Each set of tubes is capable of handling the output load without exceeding the tube rating. In normal operation, the tubes tend to share the load. However, in the case of tube failure in one half of the regulator, the two tubes in the operable half instantly and automatically carry the entire load.

The use of thyratron tubes in the power output section of the VSMR does away with circuit tuning and matching, as is the case in some other types of regulators. The output section will operate into the motor field or the generator field of any drive to accurately control speed, tension and voltage, within the rated limit of a single pair of tubes.

Available in both 6-ampere and 10-ampere outputs, based on the capacity of one set of output tubes, the new Reliance VSMR reduces industrial electronic maintenance to the same category as changing electric light bulbs in the home. A newly re-designed V*S Jr. variable-speed electronic drive was also announced.

The new V*S Jr., with its maximum size boosted from three up to four horsepower, gives wider application coverage than ever before. The compact, packaged electronic drive consists of a rectified-power control panel, an operator's station, and a variable-speed drive motor. Available in 220-volt and 440-volt models in sizes from ¾ through 4 hp, the V*S Jr. gives wide-range adjustable speed for all machine applications requiring precise control of variable speeds, including inching and jogging. At the twist of a simple rheostat control, the V*S Jr. will operate from as low as 23 rpm. for intermittent setup duty, or up to 2300 rpm for high-speed production.

Another product is a new line of space-saving right-angle gearmotors with heavy load-carrying and shock-absorbing qualities for industrial applications. The new gearmotors, in one to ten horsepower sizes for continuous-duty applications, and one to thirty horsepower for intermittent duty, are now available with such features as horizontal or vertical mountings, conventional double shaft, and hollow shaft, to fit all types of applications calling for reduced speeds.

A new Reeves Vari-Speed Motodrive, put in production in the early part of May has improved operating efficiency and extended ratios of speed variation. Each size is available in standard assemblies tailored to fit a wide range of space requirements. In addition, many motor and mounting modifications, as well as remote control features, are available for unusual installation requirements in integral horsepower ratings up to 5 hp.

Large Aluminum Billets Are Cast Continuously

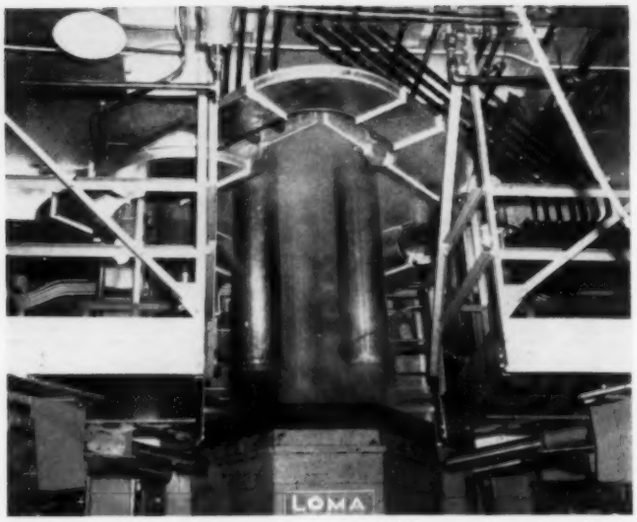


Figure 1 — Three 18-in. diam. billets are cast simultaneously on semi-continuous casting machine at Kaiser Aluminum.

▲ AMONG the outstanding features of the recently completed U.S. Air Force Heavy Press Extrusion Works operated by Kaiser Aluminum & Chemical Corp. at Halethorpe, Md., are two novel vertical "Direct-Chill" (D.C.) billet casting machines.

A wide variety of aluminum alloys is produced by the extrusion plant. Kaiser has been particularly successful in casting even highly alloyed billets with an excellent metallurgical structure, entirely free from inverse segregation. Hot metal for the casting operation is obtained from four gas-fired reverberatory furnaces having a melting capacity of 50,000 lb each. The metal flows from the holding hearth of the furnaces through a refractory-lined and electrically heated swinging trough, into a distributing pan and finally through spouts into the water-cooled aluminum molds.

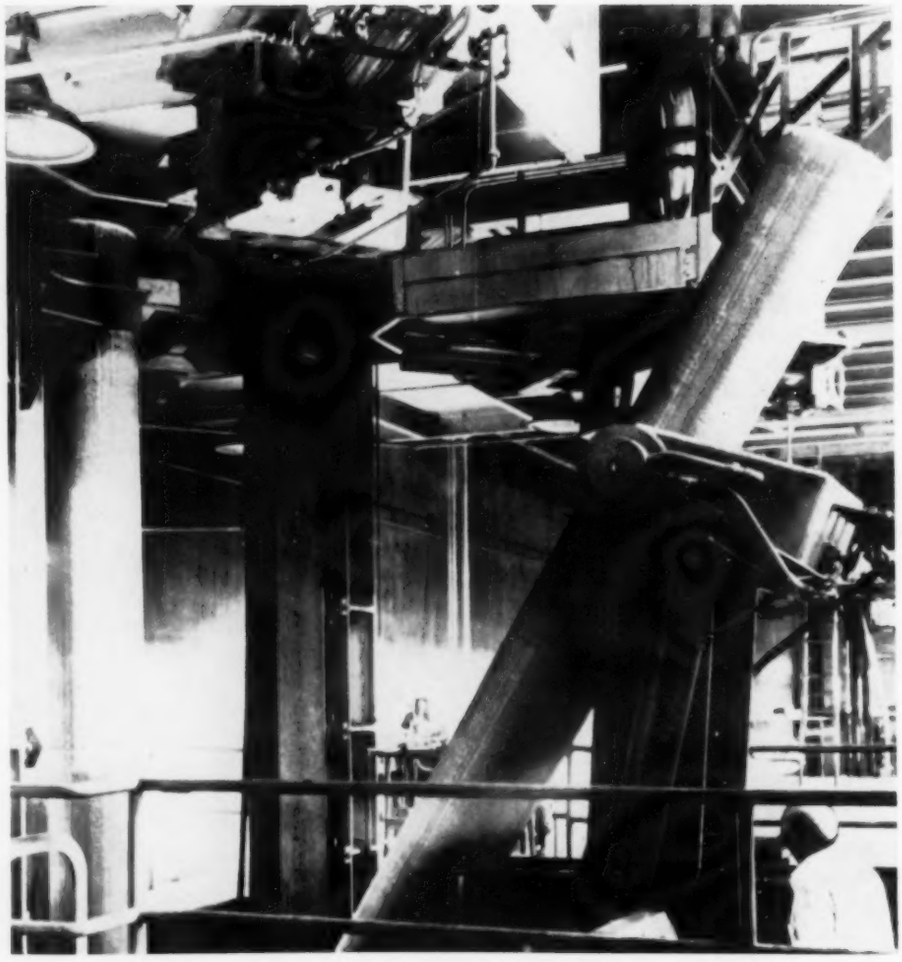


Figure 2 — The 20-in. diam. by 25-ft long billet is removed from semi-continuous casting machine.

Here's how Bearings, Inc. helped a customer save $2,000 in 60 days!

By removing bearing inventories from several departments to one centrally located stockroom, establishing records showing every application for every bearing, the bin number where these bearings are stocked and the quantity on hand, our engineers saved our customer money and made all bearings immediately available. Many identical bearings bought by several departments for many types of machines were found in quantities exceeding normal requirements. Many bearings were unuseable — unwrapped, dirty and rusty. A few of these bearings are shown above with W. J. Lukach, Bearings, Inc. sales engineer who supervised cleaning, greasing and re-wrapping all bearings not in original boxes.

THE PAYOFF OF OUR SERVICE, ACCORDING TO OUR CUSTOMER, EMPIRE STEEL CORPORATION AT MANSFIELD, OHIO, WAS A SAVING ON BEARING PURCHASES OF $2,000 IN LESS THAN TWO MONTHS.

This is not an isolated example of our services — surveys of bearing requirements, inventory control, application engineering, maintenance schedules and procedures are a regular and continuing part of our service to all customers to whom we supply replacement bearings. Ask how we can help YOU!

Providing bearing service in the territories adjacent to our branches, listed below.

BEARINGS, INC.

OHIO: Akron • Canton • Cincinnati • Cleveland • Columbus • Dayton • Elyria • Hamilton • Lima • Mansfield • Toledo • Youngstown • Zanesville
INDIANA: Ft. Wayne • Indianapolis • Muncie • Terre Haute
PENNSYLVANIA: Erie • Johnstown • Philadelphia • Pittsburgh • York
WEST VIRGINIA: Charleston • Huntington • Wheeling
NEW JERSEY: Camden • **MARYLAND:** Baltimore
DELAWARE: Wilmington •
Subsidiaries: Balanrol Corp. • Buffalo, N.Y.•
Kentucky Ball and Roller Bearing Co. • Louisville, Ky.

The fundamental concept of the D.C. casting machines at Halethorpe is a major Kaiser Aluminum engineering development. The mechanical part of these units was designed and constructed by Loma Machine Manufacturing Co., Inc. of New York City. The machines operate on a semi-continuous basis, and are capable of producing billets, up to 25 ft length and up to 20 in. diam. Depending upon the diameter being cast, each machine can produce two or more billets simultaneously. The results obtained with this casting equipment have been excellent, with the billet surface being so clean as to require no scalping prior to extrusion, even in the high-strength alloys. For the extrusion of large tubes the billets are cast hollow and then scalped internally to be used in conjunction with mandrels in the presses.

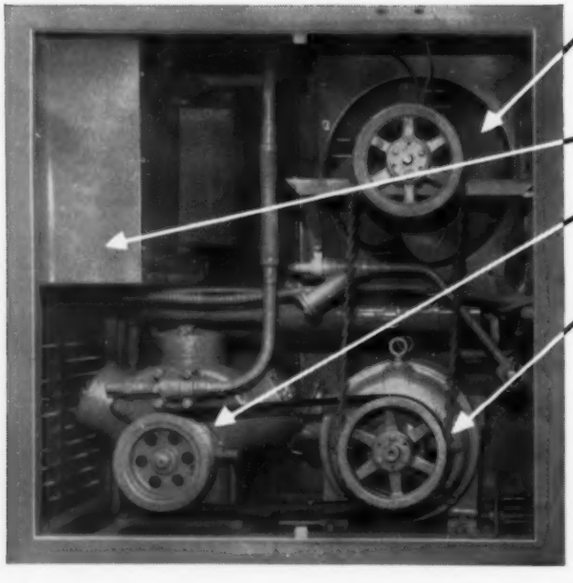
The casting machines operate at an infinitely variable billet lowering speed up to 8 in. per min., and a fixed billet lifting speed of 90 in. per min. The hydraulic equipment for lowering and lifting the mold stool supporting platform comprises a cylinder of almost 30-ft stroke, an oil-hydraulic power unit and control gear to regulate the length and rate of platform travel. The hydraulic system is capable of supporting a maximum billet load of approximately 20,000 lb.

The high productivity of the casting installation at Halethorpe is facilitated largely by the patented automatic billet removal device, also designed and constructed by Loma. This equipment eliminates the need for overhead crane facilities and insures rapid and smooth transfer of the billets from the casting machines to the receiving racks. Furthermore, it avoids the need for the mold setup to be moved during billet handling operations. As soon as an individual pour is completed, the 25-ft long billets are supported in the vertical position by a series of guides. The billet grab arm is then advanced and made to pick up one billet at a time by means of oil-hydraulic cylinders. The entire removal device is mounted on a carriage which moves on rails across the casting machine. A combination of tilting the billet grab arm, and moving the carriage away from the casting pit causes the billet to swing from the vertical beyond the horizontal position, and allows it to be unloaded to a sloped idle roller conveyor incorporating a 5-ton weighing scale. Finally, the billet is pushed onto a billet receiving rack where it is tested with an ultrasonic gage prior to transfer to either the homogenizing furnaces or the billet saw.

The Halethorpe plant is using the casting installation in the production of extrusion billets of such alloys as 6061, 6062, 2024 and 7075. Kaiser Aluminum depends on the soundness of its billets to assure the highest quality in the ultimate extruded sections shipped to the customer. In the related field of rolled aluminum alloy products, similar quality requirements apply, and another large casting installation consisting of six stations for the semi-continuous production of rolling mill slabs weighing up to 20,000 lb each is currently being built by Loma for the new Kaiser Aluminum plant at Ravenswood, West Virginia.

Advance design of Dravo Cab Conditioners

cuts crane downtime



The heavy duty construction and sturdy components of Dravo Crane Cab Conditioners assure dependable service under the most severe operating conditions. This extreme dependability helps to cut costly crane downtime.

Shown at the left is the condenser section of Dravo's 7½ hp conditioner. The large access panels have been opened to show how easily maintenance can be performed from the front of the unit. Also, you can see some of the many features which add to the efficiency and reliability of Dravo Crane Cab Conditioners.

RUGGED CONDENSER-FAN ASSEMBLY—Air is forced, not pulled, through the condenser coils. Thus, when unit is opened for inspection, system operation continues and eliminates maintenance downtime.

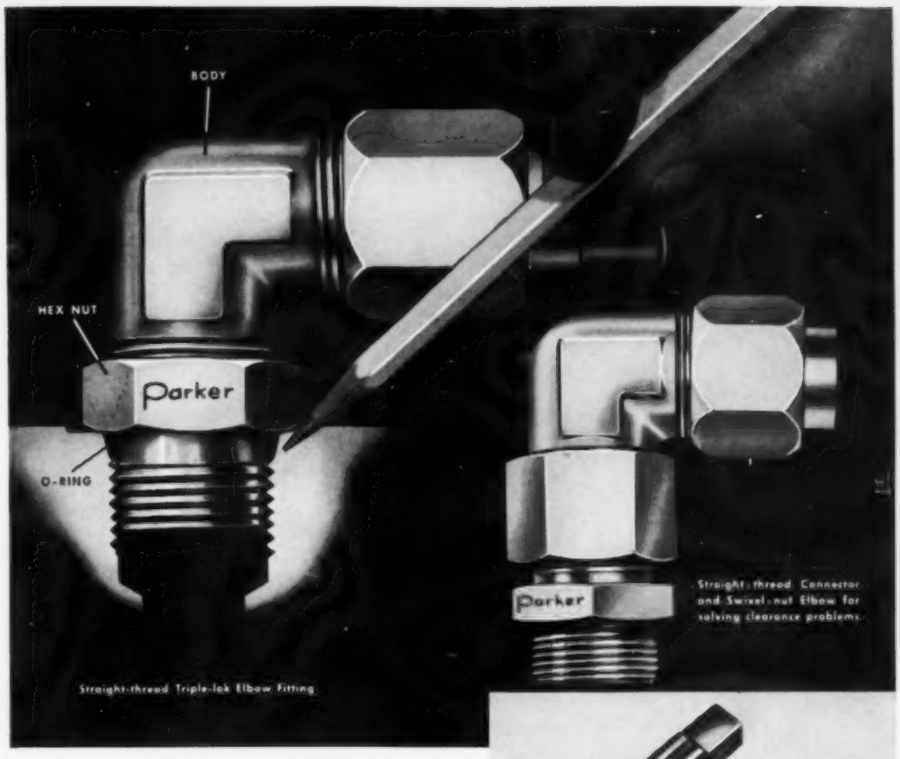
DUST-TIGHT CONTROL CABINET—Electrical controls are protected from dirt, dust, and damage.

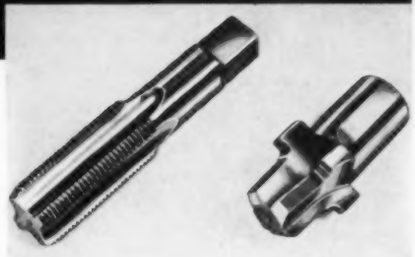
WEAR-RESISTANT COMPRESSOR—Heavy duty automotive type pistons with full pressure lubrication increase compressor life and efficiency.

HEAVY DUTY MOTOR—Class B insulation (standard equipment on 5 and 7½ hp compressor-condenser fan motors) assures efficient operation despite high ambient temperatures.

For more information about Dravo Cab Conditioners, write for Bulletin No. 1350-33, Dravo Corporation, Pittsburgh 22, Pa.

DRAVO CORPORATION





Precision thread-tapping and counterboring tools for making accurate *straight*-thread boss (to receive these new Parker *straight*-thread fittings) are now available with machining drawings from Parker.

New Parker *straight*-thread fittings solve your leakage problems

Now you can forget about high-pressure hydraulic problems resulting from tapered pipe threads. Forget about leakage . . . about the danger of cracking or distorting valve bodies by over-tightening the fittings . . . about damaged threads from over-tightening to obtain proper positioning. Forget about messy pipe "dope".

You can eliminate all of these problems by using new Parker *straight*-thread fittings with positive O-ring seals. (See illustration above.)

Parker *straight*-thread fittings are now being supplied in response to the growing demand for this new type of leakproof, trouble-free connection. They are shorter and have smaller hexes than the AN fitting for the old AND 10050 boss. *Straight* threads are available on *Triple-lok* (the industrial standard flare tube fitting) and on *Ferulok* (flareless fitting for heavy steel tubing).

This is another example of Parker's pioneering leadership in the field of hydraulic fittings. Write for Catalog.

TUBE AND HOSE FITTINGS DIVISION
Section 417
The Parker Appliance Company
17325 Euclid Ave., Cleveland 12, Ohio

Parker
Hydraulic and fluid system components

Now enjoy advantages of rubber-covered hose without stripping . . .

Use new Parker NO-SKIVE fittings

Stop stripping hose covers! New NO-SKIVE *Hoze-lok* fittings require no stripping of rubber-covered hydraulic hose. They're faster, easier-to-use . . . *and re-usable.*

Two simple steps complete the make-up: (1) Dip end of hose in oil and screw into socket counter-clockwise until hose reaches end of recess in socket. (2) Dip nipple in oil and push into socket and hose, turning clockwise to engage thread. Screw all the way in.

During step (1), the lead thread of the socket cuts through the rubber cover of the hose. This permits the threads following it to contact and grip the wire braid. It will hold beyond hose-bursting pressures . . . also under severe vibration conditions.

Send for Bulletin 4433. Mail the coupon for complete information about these new Parker *Hoze-lok* fittings. Find out how you can simplify and speed your hose assemblies.

TUBE & HOSE FITTINGS DIVISION
Section 417
The Parker Appliance Co.
17325 Euclid Ave.
Cleveland 12, Ohio

☐ Please send me your new Bulletin 4433 about NO-SKIVE Parker Hoze-lok fittings.

Name_____

Company_____

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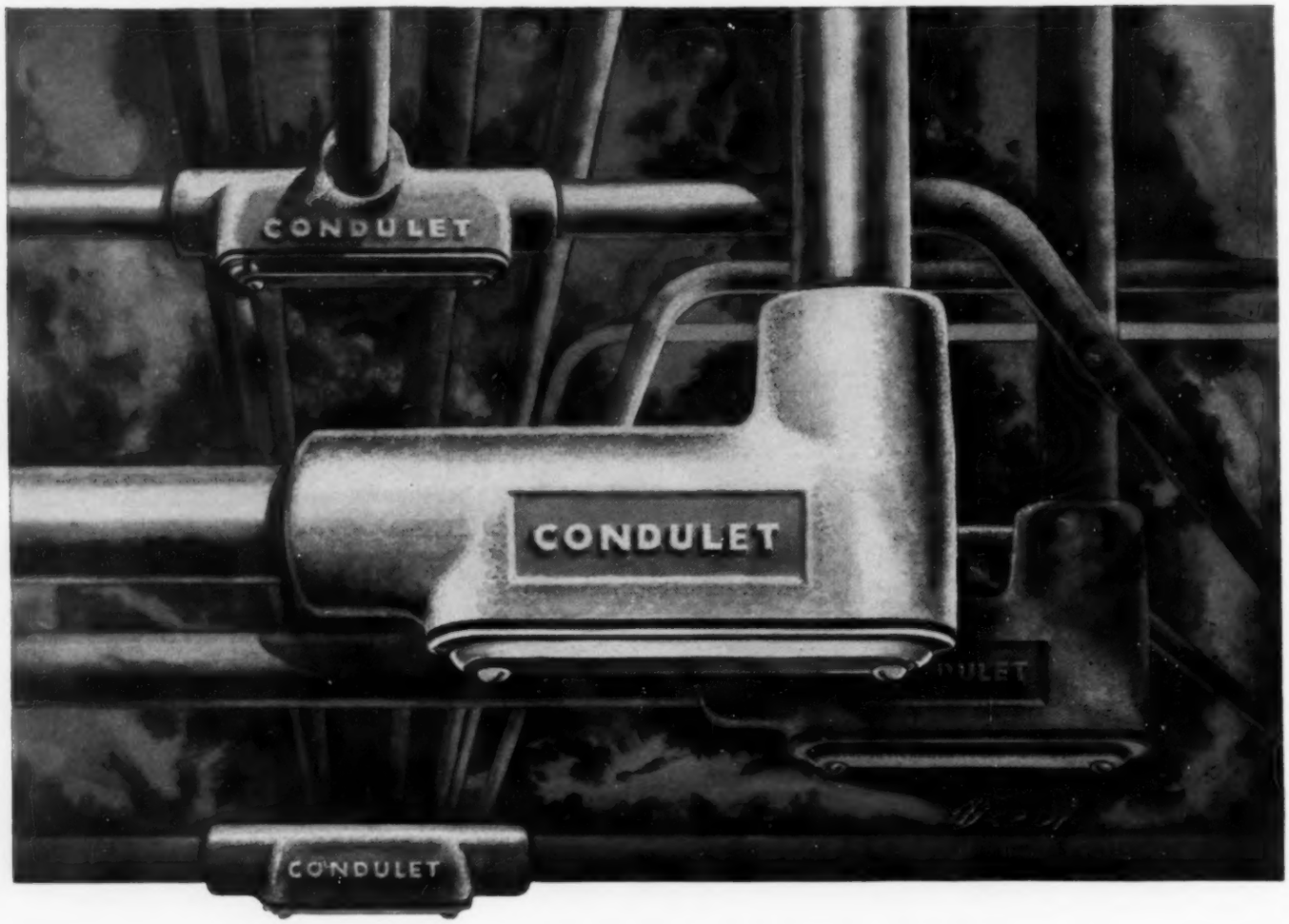
Nothing Beats

CONDULETS* and RIGID CONDUIT for FLEXIBILITY, SAFETY, ECONOMY



- **INSTALL ANYWHERE.** Crouse-Hinds Condulets and rigid conduit operate safely and efficiently under all atmospheric conditions and in all occupancies.
- **INCREASE CAPACITY EASILY.** You don't have to tear out and replace the entire system: merely pull additional wires or put in a larger size.
- **ASSURES MAXIMUM SAFETY.** Condulets are Taper-Threaded to provide a permanent low resistance path to ground.
- **GREATER DURABILITY.** Condulets and rigid conduit provide circuits with more protection against physical damage than any other wiring system. Further, Condulets are made of galvanized cast Feraloy, and resist corrosion.
- **LOWER OVER-ALL COST.** First cost is the entire cost — a minimum of maintenance is required.

COMPLETE FLEXIBILITY

There's a Condulet to meet every need of complex modern electrical layouts. See your Condulet Catalog.

A NATIONWIDE DISTRIBUTION exclusively through ELECTRICAL DISTRIBUTORS

*CONDULET is a coined word registered in the U.S. Patent Office. It designates a product made only by the Crouse-Hinds Company.

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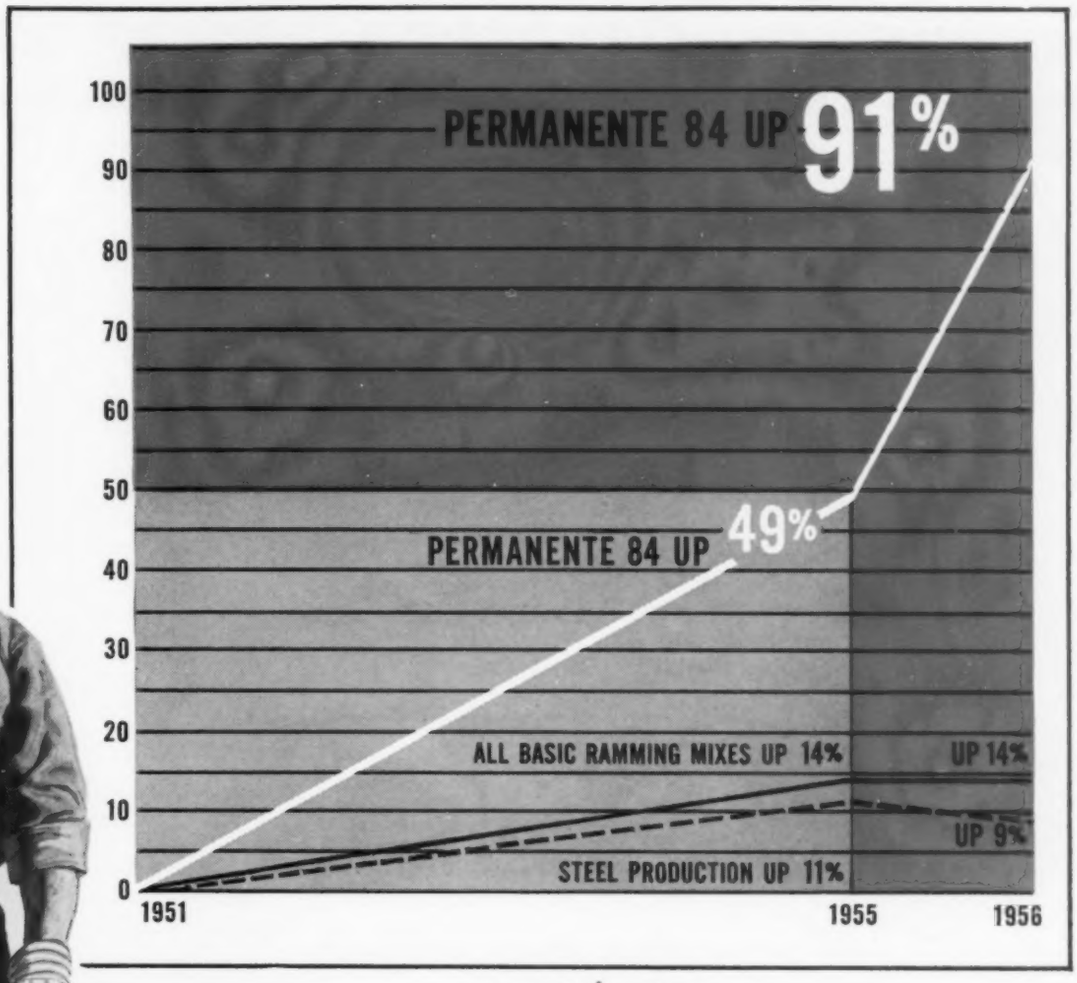

Why this ~~growing~~ *soaring* preference for Permanente 84 Ramming Mix?

A year ago, we ran an ad showing how sales of Permanente 84 to steel producers had increased 49% during the same 5-year period that sales of all basic ramming mixes increased only 14%.

But now after just one more year, steel producers' preference for Permanente 84 has pushed its sales increase up to *a whopping 91%!*

Why such an overwhelming preference? Briefly, here are the reasons:

Permanente 84 reduces the cost of maintaining furnace bottoms and banks. Repairs made with Permanente 84 stay put! Down time for hot repairs is reduced. Steel production goes up—costs come down. Ideal for hot patching both open hearths and electric furnace banks and bottoms.

Order Permanente 84 now and get extra steel tonnage at lower cost.

Call or write Kaiser Chemicals Division, Dept. R7441, Kaiser Aluminum & Chemical Sales, Inc., at any of the addresses listed below:
PITTSBURGH 22, PA. . . . 3 Gateway Center
HAMMOND, IND. . . . 518 Calumet Building
OAKLAND 12, CALIF. . . . . 1924 Broadway

CHEMICALS KAISER REFRACTORIES

Kaiser Chemicals

Pioneers in Modern Basic Refractories

Refractory Brick and Ramming Materials • Castables & Mortars • Magnesite • Periclase • Deadburned Dolomite

TORRINGTON *TAPERED ROLLER* BEARINGS

Accurately caged... to cut your costs!

The one-piece, cast-bronze cage you see above is one of the reasons why TORRINGTON Roller Bearings give long, low-cost service. Note the individual roller retainment, for example. This helps keep the rollers thoroughly lubricated at all times. Race surface inspection is simplified. The machined pads in each roller pocket make sure the rollers are guided accurately at the pitch line. All this to minimize wear... lengthen bearing life.

Yes, TORRINGTON Roller Bearings cut your costs. They're made of the finest bearing quality steel available, heat treated by the most modern methods. No wonder they're so rugged... so dependable. Specify TORRINGTON *Tapered* or *Cylindrical* Roller Bearings for heavy loads and low maintenance.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District offices and distributors in principal cities of United States and Canada

TORRINGTON BEARINGS
Spherical Roller • Tapered Roller • Cylindrical Roller
Needle • Ball • Needle Rollers

For Dust Collection...

Western Precipitation
presents
its latest development
in a quarter-century of
continuous advancement
in Mechanical Collectors

...The "9VGR" MULTICLONE!

Over 25 years ago

Western Precipitation Corporation pioneered the high-efficiency multiple-tube principle that has proven so superior it is now the pattern for the industry.

The Multiclone continues to be years ahead of all other centrifugal collectors because it incorporates the invaluable "know-how" gained through these many years of leadership in the field —leadership that is further emphasized by introduction of the 9VGR Multiclone, another important milestone in Multiclone's quarter-century of outstanding performance.

COTTRELL Electrical Precipitators
MULTICLONE Mechanical Collectors
CMP Combination Units
DUALAIRE Reverse-Jet Filters
HOLO-FLITE Processors

NEW 9VGR FEATURES...

1. *No need for continuous external support.*
2. *Easier and less costly to insulate.*
3. *Minimum dust stratification.*
4. *Improved dust distribution to all tubes.*
5. *Simpler installation, lower erection costs.*
6. *Freedom from leakage at all critical points so that full collection efficiency is obtained.*

Plus **The proven superiority of CAST IRON TUBES and VANES!**

Through the years, others have tried special alloy steels and so-called "miracle" metals, but nothing has proven as satisfactory *in actual field service* as cast iron. In the past quarter-century more than 270,000 Multiclone tubes have been placed in service with less than 1.85% replacement—*a performance record unequalled in the industry!*

There are many other advantages built into the 9VGR. There is a Multiclone representative near you who will be glad to supply complete details. Or write direct, asking for your free copy of Bulletin #M209 which contains full details.

Western Precipitation Corporation

Designers and Manufacturers of Equipment for Collection of Suspended Material from Gases ... and Equipment for the Process Industries

Main Offices: **1067 WEST NINTH STREET, LOS ANGELES 54, CALIFORNIA**

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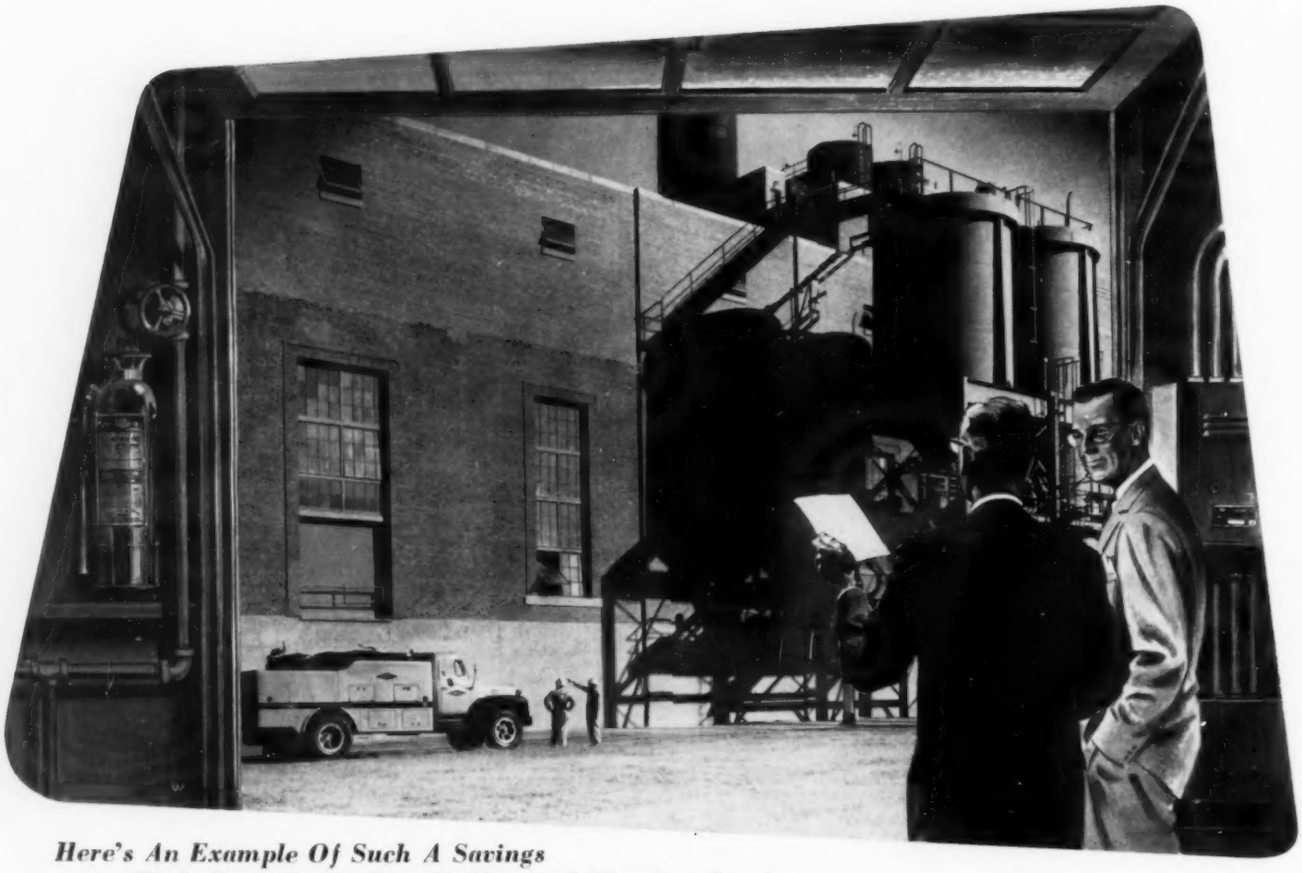
Representatives in all principal cities

how much could you add to your profit-- by saving $50,000 per boiler cleaning?



Here's An Example Of Such A Savings Made Possible By Dowell Chemical Cleaning Service

Dowell recently chemically cleaned a 1,000,000 lb. per hour steam generator for one of its customers. Total outage time was 43 hours. This saved the company an estimated five to seven days down-time, as compared to mechanical cleaning methods.

Considering replacement power for a boiler of this capacity costs between $7,000 and $15,000 per day, it's easy to see a $50,000 savings. And, it's just as easy to project a $250,000 to $500,000 annual savings for a plant with five to ten such boilers.

This particular case history concerns a power company with a forward-looking operations manager. But, Dowell has other startling performance data to show you — from your own industry. That's because chemical cleaning is so versatile. Dowell engineers are experts in removing scale and sludge from process systems, tanks and piping. They apply solvents in various ways— such as filling, jetting, cascading. Dowell furnishes all the necessary chemicals, trained personnel, pumping and control equipment.

For specific information on how chemical cleaning can help you to greater profits, call the Dowell office near you. Or write Dowell Incorporated, Tulsa 1, Oklahoma.

have Dowell clean it chemically DOWELL

A SUBSIDIARY OF THE DOW CHEMICAL COMPANY

Date-line Diary...

April 1

▲ The AISI reports that the operating rate of the steel industry for the week of April 1 is scheduled at 91.6 per cent of capacity. This is equivalent to 2,344,000 tons compared with 2,364,000 tons one week ago and 2,406,000 tons one year ago. Index of production for the week is 145.9.

April 2

▲ Senator Byrd (D. Va.) reported U. S. monthly payroll for civilians reached $1,000,000,000 in January. Senate majority leader Johnson (D., Texas) promptly called on the administration to launch a "cost consciousness" program to curb spending.

▲ Great Lakes iron ore shipping season opened as the steamer L. E. Block, Inland Steel Co., left Escanaba destined for the Indiana Harbor Works with a 13,000-ton cargo of iron ore.

April 3

▲ Custom smelters sold moderate amounts of copper at 31½ and 32¢ per lb, unchanged to ½¢ higher than Monday. Union Minier, increased price nearly ½¢ to 30¾¢ in Belgium, and 29.85¢ in New York.

April 4

▲ ICC refused to permit reduced rates on carload shipments of iron ore from Boston ports to the Youngstown area. The reduction to a proposed rate of $3.03 a gross ton from existing rate of $8.25 was ruled not just and reasonable.

▲ Steel scrap prices in the Pittsburgh district fell an additional $9 a ton to $43 on No. 1 heavy melting grade, representing a decline of $24 a ton since early January.

April 5

▲ The Commerce Dept. reported that personal income in February climbed to a new high, reaching a yearly pace of $336,700,000,000 or $1,700,000,000 above the January, 1957 rate, and $21,600,000,000 above the rate in February, 1956.

▲ The Bureau of Mines reports that the consumption of scrap during February, 1957 totaled 6,043,000 gross tons and pig iron 5,870,000 gross tons compared with 6,630,804 gross tons of scrap and 6,482,472 tons of pig iron in January, 1957.

April 8

▲ The AISI reports that the total shipments of finished steel products for February, 1957 amounted to 7,066,732 net tons, compared with 7,809,451 net tons in January, 1957 and 7,468,393 net tons in February, 1956.

▲ The AISI reports that the operating rate of the steel industry for the week of April 8 is scheduled at 91.0 per cent of capacity. This is equivalent to 2,328,000 tons compared with 2,319,000 tons one week ago and 2,483,000 tons one year ago. Index of production for the week is 144.9.

▲ Commerce Secretary Weeks reported that jobholders in March rose to 63,865,000 an increase of 675,000 over February and 971,000 above March, 1956; unemployed in March numbered 2,882,000, down 239,000 from February and 134,000 less than March, 1956.

April 9

▲ An $81,000,000 increase in expansion plans has been arranged by Kaiser Steel which will result in an outlay of $194,000,000; and almost double the corporation's steelmaking capacity.

▲ The Bureau of Statistics reported that Canadian pig iron output in March, 1957 amounted to 335,012 tons, compared with 292,642 tons in March 1956, the total for the first quarter of 1957 was 931,649 tons compared with 846,183 in 1956. Steel ingot production in March amounted to 459,969 tons compared with 429,720 tons in March, 1956; the first quarter production totaled 1,329,884 tons compared with 1,246,174 for the same period in 1956.

▲ Beginning next January 1, tin mill products produced by the operating division of U. S. Steel Corp. will be billed on the basis of price in effect at time of shipment, replacing the current method of firm commitments for a six-month period.

▲ U. S. Steel ordered a gas turbine blower for supplying air in blast furnace operations to be installed at the South works in Chicago by Westinghouse.

April 11

▲ Government figures show that construction outlays for the first quarter of 1957 totaled nearly $9,200,000,000; on a seasonally adjusted basis this compares as $44,800,000,000 in 1957 against $44,300,000,000 in 1956.

▲ La Consolidada, S. A., reported net income of $548,129, equal to 83¢ per share unaudited, for the first quarter of 1957, compared with $368,806 for the same period in 1956.

April 12

▲ House starts in March, 1957 dropped to an annual rate of 880,000 units, compared with 910,000 in February, 1957 and 1,094,000 in March, 1956.

April 15

▲ The AISI reported that imports of iron ore in 1956 of 34,000,000 net tons reflecting American investments in the development of foreign iron ore deposits.

▲ According to the AISI, production of ingots and steel for castings in March, 1957 totaled 10,591,000 net tons compared with 10,924,788 tons in March, 1956; production in the first quarter of 1957 equalled 31,586,968 net tons compared with 31,872,014 net tons for the same period in 1956.

▲ Woodward Iron and the AFL-CIO United Steelworkers signed a three-year pact last Thursday, April 11, ending a 162-day strike. Woodward reported a loss of approximately 324,000 tons of pig iron production and estimated workers lost about $5,600,000 in wages.

▲ Copper prices were down ½¢ from previous quotations, sales were made at 31¢ a lb.

▲ The first observance of Good Friday as a contractual holiday will cause steel production to decline in Pittsburgh and Chicago this week.

▲ The AISI reports that the operating rate of the steel industry for the week of April 15 is scheduled at

89.7 per cent of capacity. This is equivalent to 2,297,000 tons compared with 2,310,000 tons one week ago and 2,466,000 tons one year ago. Index of production for the week is 143.0.

▲ The Bureau of Mines reported that imports of iron ore in December, 1956 totaled 1,630,144 gross tons valued at an average of $7.72 per ton, or $12,591,355. For the year 1956 imports totaled 12,591,355 gross tons at $8.23 per ton average or $250,243,649. In December, 1956 iron ore mine production in the United States amounted to 4,837,242 gross tons, shipments 4,448,267 gross tons, total mine stocks at December 31, 1956 were 5,698,964 gross tons. Total U. S. production in 1956 amounted to 97,300,000 gross tons, shipments totaled 96,340,000 gross tons. Exports of iron ore in December, 1956 totaled 118,070 gross tons; and for the year 1956 equalled 4,502,142 gross tons.

April 16

▲ General Electric reported sales amounting to $1,048,850,000, and earnings of $64,006,000 or 73¢ per share for the first quarter of 1957 compared with sales amounting to $946,458,000, earnings of $54,962,000 or 63¢ per share for the first quarter of 1956.

April 18

▲ The Aluminum Assn. reports primary aluminum production in the United States during March, 1957 was 135,733 short tons compared with 119,059 short tons in February, 1957 and 145,895 short tons in March, 1956.

▲ ARCI reports that deliveries of new domestic freight cars in March, 1957 totaled 9772 compared with 8184 in February, 1957 and 5949 in March, 1956. Orders totaled 5359 cars in March, 1957 compared with 6065 cars in February, 1957 and 1618 cars in March, 1956. Backlog of cars on order on April 1 totalled 107,708 compared with 111,965 on March 1.

▲ The Commerce Dept. reported that personal income for March, 1957 was at an annual rate of $337,600,000,000, $1,000,000,000 higher than February, 1957, and a gain of $19,000,000,000 over the yearly pace in March, 1956.

▲ Aluminium, Ltd., Canada, announces the development of an automatic process for the production of impact-extruded, seamless aluminum cans.

▲ George H. Love, chairman of Pittsburgh Consolidation Coal Co., in a report to stockholders, predicted that soft coal production in the U. S. in 1957 will hold around the 1956 output of 500,000,000 tons; this estimate is 16,000,000 tons less than the recent prediction by the National Coal Assn.

April 19

▲ President Eisenhower, in a letter to House Speaker Rayburn, cut his request for new appropriations for fiscal 1958 by almost $1,900,000,000, citing that actual government spending would not be much reduced unless Congress revises some programs now required by law.

▲ Business loans by leading New York banks increased $115,000,000 in the last week.

▲ Copper was reported available at 30½¢ a lb compared with prices of 31¢ quoted by custom smelters and 32¢ by big producers.

April 22

▲ The Industrial Heating Equipment Assn. reported that orders for industrial furnaces during March, 1957 amounted to $9,090,019, compared with $7,025,034 for March, 1956.

▲ United Engineers & Constructors, Inc., have been awarded a contract by Lukens Steel for engineering and construction in connection with Lukens' $38,000,000 expansion which will boost the company's rated ingot capacity from 750,000 tons a year to more than 925,000 tons.

▲ The AISI reports that the operating rate of the steel industry for the week of April 22 is scheduled at 90.3 per cent of capacity. This is equivalent to 2,310,000 tons compared with 2,313,000 tons one week ago and 2,473,000 tons one year ago. Index of production for the week is 143.8.

April 23

▲ J. L. Mauthe, chairman, The Youngstown Sheet and Tube Co., announced that the company intends to increase ingot capacity by 500,000 tons in 1957. A new tinplate mill at Indiana Harbor was brought into limited operation during the first quarter of 1957, and it is expected that the new seamless tube mill there will begin operating in October.

▲ The Aluminum Assn. reported net shipments of aluminum sheet and plate totalled 100,150,000 lb during February, 1957 compared with 115,115,000 lb in January, 1957; shipments of aluminum foil in February, 1957, equalled 13,405,764 lb compared with 15,554,670 lb in January, 1957.

▲ F. W. Dodge Corp. reported that construction contracts in the United States in March totaled $3,077,997,000, 11 per cent over March, 1956.

▲ Shipments of machine tools in March, 1957 amounted to $89,800,000, 15 per cent over February, 1957 and 20 per cent over March, 1956. Orders in March equalled $60,000,000, about ⅓ less than in March, 1956. Shipments for the first quarter, 1957 reached $244,100,000 compared with $193,400,000 in this period during 1956; new orders for this period equalled $181,500,000 compared with $187,600,000 in the first quarter of 1956; backlog at the end of the first quarter stood at 5.5 months.

▲ The government consumer price index in March rose to 118.9 per cent of the 1947–49 average an increase of 0.2 per cent during the month, and 3.7 per cent higher than in March, 1956. About 1,400,000 U. S. Workers will receive cost-of-living increases in wages of one to three cents per hr as a result of this increase. The Bureau of Labor Statistics reported that weekly real earnings of factory workers after taxes dropped slightly in March for the first time in 2½ years, for a worker with three dependents, they dropped to 121.5 per cent of the 1947–49 average from 121.9 per cent in March, 1956.

▲ Resistance Welder Mfrs. Assn. reports shipments by members during March, 1957 exceeded $3,000,000, and report a backlog of nearly $13,500,000 at March 31, 1957.

▲ Reynolds Metals Co. announced that they are holding options on approximately 55 acres of land in Louisville, Ky., on which they plan to build a product research and development center and office building.

April 25

▲ Ralph J. Cordiner, president of General Electric, predicted a 15 per cent increase in sales in 1957 over 1956 sales of nearly $4,100,000,000.

▲ Westinghouse Electric Corp. reported sales for the first quarter of 1957 at $475,686,000, net income $14,198,000 or 82¢ per share; this compares with sales for the first quarter of 1956 at $225,366,000, loss of $18,575,000, or $1.14 per share. The major plants of the corporation were out on strike in 1956.

STEEL MEN!

WHAT IS THE COST OF A "CORHART BALANCED TANK"?

•

BECAUSE Corhart Electrocast sells for several times more than ordinary clay blocks, some operators have gotten the impression that a Corhart tank costs three or four times more than an all-clay furnace.

Nothing, however, could be further from the truth. By *balancing* his furnace with the proper amount of Electrocast, the average Corhart customer adds so little to the installation cost that the difference is repaid by a *fractional part of the extra production gained.*

If you have never obtained an estimate for a Corhart Balanced Tank, (a tank with all vulnerable spots fortified by Electrocast), we believe you will be more than surprised at the low cost for which this ideal type of installation can be made . . . . Send us the plans of your furnace, with a brief description of its past history. Using the experience gained in designing 65 Corhart Balanced Tanks, we will gladly recommend the amount and location of Electrocast needed to *balance* your furnace, and submit for your consideration complete blue-prints and quotations . . . . This service will cost you nothing, but it will probably prove the most interesting reading of the year. No obligation—and no high-pressure "follow-up." *Address:* Corhart Refractories Co., Incorporated, 16th and Lee Streets, Louisville, Kentucky.

QUALITY ECONOMY ENDURANCE

CORHART ELECTROCAST REFRACTORIES

WE RAN this ad for a Corhart Electrocast Refractory a little over 25 years ago—back when only a handful of glass manufacturers would think of using this new product, "one of the world's highest-priced refractories". Yet today virtually every furnace in the glass industry uses Corhart Electrocast . . .

Today Corhart 104 is new in the steel industry. And although it too is "one of the world's highest-priced refractories", it offers open-hearth furnace operators the same opportunties for greater production and lower costs that Corhart Electrocast brought to the glass industry.

Would you like to have complete data? Address: Corhart Refractories Co., *Incorporated*, 1630 West Lee Street, Louisville 10, Kentucky, U.S.A., SPring 8-4471.

QUALITY ECONOMY ENDURANCE

CORHART 104 ELECTROCAST REFRACTORY

The words "Corhart" and "Electrocast" are registered Trade Marks which indicate manufacture by Corhart Refractories Company, *Incorporated*. Corhart Refractories Co., *Incorporated*, 1600 West Lee Street, Louisville 10, Kentucky, U.S.A.—Telephone SPring 8-4471.

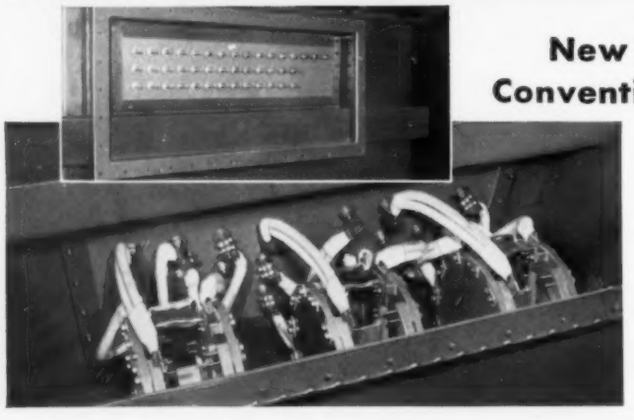
TAP-CHANGING downtime reduced from hours *to minutes!* That's the profit advantage you get with the improved tap-changing arrangement on Allis-Chalmers furnace transformers. Tap leads are brought directly to a motor-operated tap changer housed in a *separate* compartment. The ease with which taps can be changed is the secret behind the outstanding time conservation.

Advantages of Separate Compartment Located On the Side

- Affords convenience of changing taps from floor—eliminates hazards associated with top-of-transformer work.
- Eliminates possibility of objects dropping into tank.
- Reduces height of tank by eliminating terminal board.
- Main tank need only be opened for periodic inspection.

Furnace Transformer

Tap Sequence Changed in Minutes!



New Selectoheat Arrangement Eliminates Conventional Multi-Position Terminal Board

All primary taps are brought out of the main tank through a panel to the tap changer compartment. Panel completely isolates compartment from main transformer tank.

Get all the facts. See your A-C representatives or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

Selectoheat is an Allis-Chalmers trademark.

ALLIS-CHALMERS

A-5391

▲E. W. Bliss Co. sales for the first quarter of 1957 amounted to $21,281,363, net profit $787,000, or 78¢ a share compared with sales of $18,635,067, net profit of $677,764, or 68¢ a share in 1956.

▲ American Can Co. announced construction started at its Milwaukee plant of facilities for processing tinplate and steelplate in continuous coils.

April 29

▲ The AISI reports that the operating rate of the steel industry for the week of April 29 is scheduled at 89.0 per cent of capacity. This is equivalent to 2,278,000 tons compared with 2,269,000 tons one week ago and 2,373,000 tons one year ago. Index of production for the week is 141.8.

April 30

▲ AISC reports that shipments of fabricated structural steel for March, 1957 amounted to 305,009 tons compared with 278,453 tons in February, 1957 and 306,760 tons in March, 1956; bookings in March, 1957 amounted to 289,103 tons compared with 265,894 tons in February, 1956 and 365,517 tons in March, 1956. Backlog on March 31 amounted to 3,453,915 tons.

▲ Shipments abroad in the nine months ended March 31 amounted to $3,600,000,000, 44 per cent above the same period in the previous year, and included farm exports of $450,000,000 in March, 1957.

▲ Canadian Steel Foundries (1956) Ltd., and English Steel Corp., Ltd., Sheffield, England, have formed a new company, Canadian Steel Wheel, Ltd., to manufacture wrought steel railway wheels in Montreal. The new company's plant construction will begin immediately, to be finished in mid-1958, with an annual capacity of 200,000 wheels and will be situated adjacent to the Canadian Steel Foundries, Ltd. plant in Montreal East, Canada. This is the first time steel railway wheels will be manufactured in Canada.

▲ Executives of American Can Co. and the Dixie Cup Co. announced merger arrangements had been agreed on.

▲ The Commerce Dept. reported that manufacturers sales in March, 1957 amounted to $28,900,000,000, down $200,000,000 from February, 1957; inventories, on a seasonally adjusted basis, at the end of March totaled $52,200,000,000, $300,000,000 higher than February, 1957.

▲ Crucible Steel Co. of America announced a $1,500,000 expansion program for Vacuum Metals Corp., to double the company's capacity for producing high purity vacuum-melted materials. It will include a new vacuum induction furnace, a new melt shop building to house the furnace, a new metallurgical-chemical laboratory building for production control and development.

▲ Directors of Algoma Steel Corp., Ltd. voted a $2.00 per share dividend and proposed a four-for-one stock split. The $2.00 dividend is applicable for the half-year period; after June dividends will be considered on a quarterly basis.

▲ The Bureau of Census, Dept. of Commerce report that shipments of iron and steel castings in January, 1957 amounted to 1,468,432 short tons compared with 1,344,070 short tons in December, 1956 and 1,501,698 short tons in January, 1956. In February, 1957 these shipments amounted to 1,336,078 short tons compared with 1,473,700 short tons in February, 1956.

STEEL COMPANY QUARTERLY FINANCIAL REPORTS—JANUARY 1, 1957 TO MARCH 31, 1957

	1957 Net sales	1957 Net profit	1957 Earnings per share	1956 Net sales	1956 Net profit	1956 Earnings per share
Acme Steel Co.	$ 44,213,939	$ 2,234,451	$0.94	$ 31,436,666	$ 1,916,666	$0.97
Alan Wood Steel Co.	18,529,732	628,752	0.82	17,338,439	689,172	0.88
Allegheny Ludlum Steel Corp.	81,294,626	4,790,665	1.25	74,774,665	4,572,608	1.23
Armco Steel Corp.	198,205,419	15,013,858	1.25	189,958,346	16,699,609	1.39
Barium Steel Corp.	33,960,484	2,058,055	0.51	27,150,118	1,468,957	0.44
Bethlehem Steel Corp.	676,107,988	53,427,655	1.24	599,556,156	44,963,787	1.04
Colorado Fuel & Iron Corp.	.....	4,552,392	1.30	.....	4,016,414	1.14
Continental Steel Corp.	11,121,959	662,262	1.32	12,495,065	728,643	1.45
Copperweld Steel Co.	25,983,173	761,667	0.89	25,078,064	971,898	1.21
Crucible Steel Co. of America	70,598,795	3,372,606	0.93	69,250,787	3,680,966	1.01
Detroit Steel Corp.	24,653,058	1,008,166	0.31	30,233,225	2,178,832	0.69
Eastern Stainless Steel Corp.	13,962,335	661,421	1.09	12,107,400	913,189	1.51
Granite City Steel Co.	33,695,881	3,404,451	1.59	35,957,078	3,843,801	1.79
Inland Steel Company	203,649,640	14,613,704	2.59	190,380,288	14,015,549	2.54
Interlake Iron Corp.	30,036,458	1,725,987	0.77	25,587,409	1,752,160	0.90
Jessop Steel Co.	.....	544,886	1.10	.....	314,353	0.64
Jones & Laughlin Steel Corp.	203,965,000	12,823,000	1.89	195,272,000	13,559,000	2.00
Keystone Steel & Wire	30,572,113	2,066,798	1.10	32,903,836	2,750,117	1.47
Kaiser Steel Corp.	54,925,630	7,784,118	2.22	50,913,084	4,127,592	1.11
Lone Star Steel Co.	.....	3,288,951	1.25	.....	2,243,867	0.85
Lukens Steel Co.	.....	3,365,498	3.53	.....	1,361,641	1.43
McLouth Steel Corp.	.....	3,111,285	...	.....	2,084,702	...
National Steel Corp.	176,858,209	13,501,506	1.82	170,605,918	14,102,586	1.91
Pittsburgh Coke & Chemical Co	13,624,000	908,000	0.70	14,527,000	834,000	0.64
Pittsburgh Steel Co.	49,786,939	2,011,260	1.10	49,944,199	2,469,624	1.39
Republic Steel Corp.	354,406,193	28,052,826	1.81	332,598,475	25,041,392	1.62
Rotary Electric Steel	13,805,930	493,279	0.64	13,565,113	613,220	0.79
Sharon Steel Co.	47,655,789	1,592,644	1.45	50,147,561	2,257,871	2.05
Superior Steel Corp.	.....	227,335	0.67	.....	192,639	0.57
United States Steel Corp.	1,166,484,088	115,478,109	2.03	1,100,543,080	104,160,945	1.83
Washington Steel Corp.	.....	615,947	1.02	.....	447,999	0.73
Wheeling Steel Corp.	71,344,000	4,559,000	2.12	67,855,000	5,280,000	2.50
Youngstown Sheet and Tube Co.	192,075,871	10,607,267	3.09	177,885,632	10,193,856	3.01

WITH CARD PROGRAM CONTROL:

STANDARD BUSINESS CARD—for flexibility and compatibility with business accounting, industrial data logging and processing systems—is key to the General Electric program control system.

PUNCHED CARDS permit operator to maintain large number of optimum schedules for a wide variety of products.

ACCURACY of the system is approximately 0.010 inches with maximum opening of 9.99 inches. Settings are provided every 0.01 inches. Above is control panel for the General Electric control system.

Allegheny Ludlum gets higher quality with faster schedule changes, automatically

New General Electric punched card control on Allegheny Ludlum's Brackenridge reversing rougher is steel industry's first card programmed control system

For the first time in the history of the steel industry, a punched card system automatically programs and controls roll openings and mill speed. This newly developed General Electric punched card system provides closer tolerances and is presently in full operation on Allegheny Ludlum's Brackenridge reversing rougher. The system is designed to help eliminate errors in roll settings and speed and represents a new standard for quality control and process flexibility.

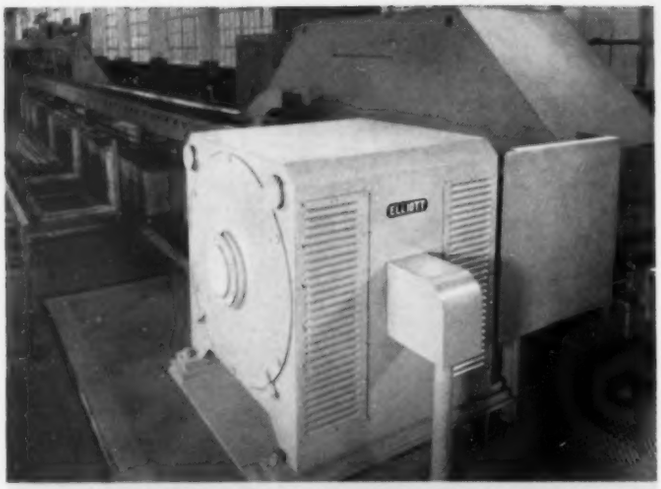
A 15 Pass Schedule and product data can be programmed into Allegheny Ludlum's roughing mill. The punched card control system automatically sets the screws and the top speed of the pass. The operator selects the desired card and inserts it in the "card reader". The operator then starts the pass with a start-stop push-button. For every pass, the screws are automatically set with the precision necessary for higher quality production.

The Card Program Control system was designed and developed by the General Electric Company. Applied to other processes, the control principle promises greater process flexibility with higher quality control for the steel industry.

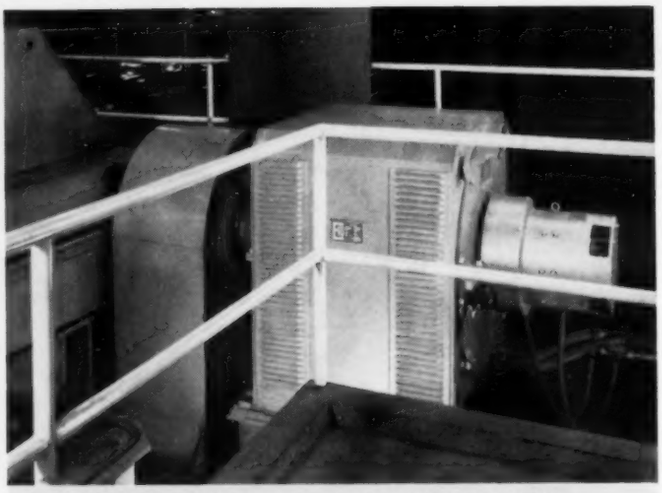
Get Complete Information on how a General Electric card program control system can benefit your operation from your nearest General Electric Apparatus Sales Office. General Electric Co., Section 659-115, Schenectady, New York.

Engineered Electrical Systems for the Steel Industry

GENERAL ELECTRIC



This Elliott 400-hp, 900-rpm, drippproof, squirrel-cage induction motor drives a triple-die drawbench at the Torrington Division of The American Brass Company.



At the Reading Tube Corporation, this Elliott 500-hp, 900-rpm, drippproof, synchronous motor, with direct-connected exciter, drives a drawbench.

Here an Elliott d-c motor, 100-hp, 400/1200-rpm, force-ventilated with top-mounted blower and filter, serves the Revere Copper and Brass, Inc.

They're designed for the toughest applications...

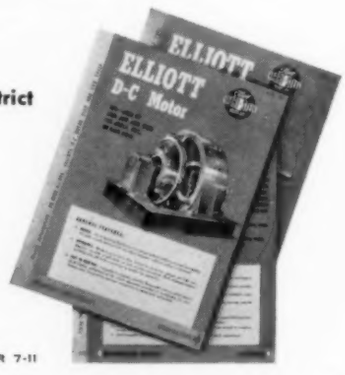
assure **TOP PERFORMANCE**... permit **EASY MAINTENANCE**

The illustrations above show three types of Elliott motors—squirrel cage, synchronous, and direct current—employed for drawbench drives. Extensive experience permits Elliott engineers to recommend and successfully apply the type of motor best suited for each individual drive. The rugged construction of Elliott motors insures dependable operation, even in the most difficult operating conditions.

All Elliott motors have the sturdy frames needed *for enduring strength and rigidity* . . . the well-insulated and securely-braced coils required *for long life* . . . and offer a variety of styles of well-designed bearings *to meet individual operating conditions.* Advanced designs incorporate the latest engineering and structural developments, and provide easy accessibility for routine inspection and maintenance.

Elliott engineers will gladly give you the benefit of their wide experience, whether your requirements may be for a complete new system layout, or a modernized existing installation.

Call your nearest Elliott district office *today*, or write for descriptive literature.

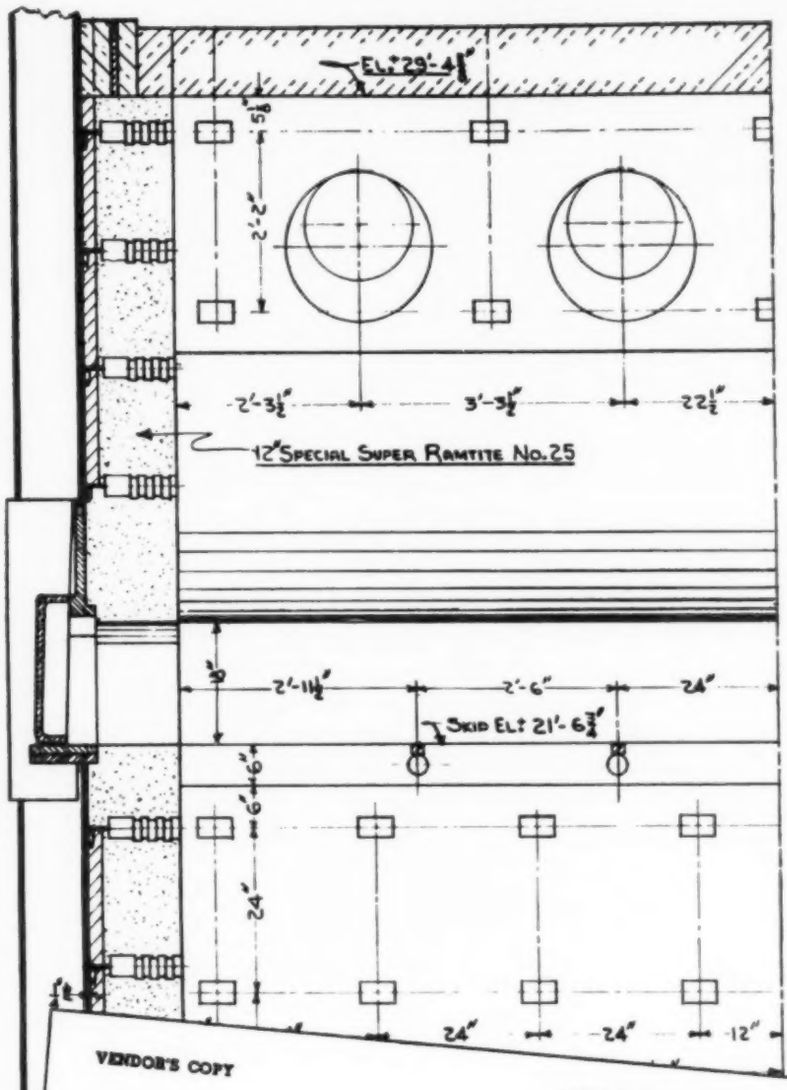


ELLIOTT Company

Ridgway Division • **RIDGWAY, PENNSYLVANIA**

R 7-11

Past Performance Paves the Way for Ramtite® in New Design Billet Heating Furnaces



In 1954, Ramtite was installed in the side and burner walls of two billet heating furnaces at a midwestern steel mill. These furnaces were recently completely redesigned by Flinn & Dreffein Engineering Co., and once again Ramtite was ordered for the side walls and burner walls. Here's why!

1. *Increased furnace capacity*—High thermal efficiency permits a 25% to 30% reduction in thickness over standard wall construction—with no increase in heat loss.

2. *Fuel savings*—Monolithic construction eliminates joints—reduces air and gas leakage as never before.

3. *Low maintenance*—Inherent spall resistance assures longer refractory life.

The Ramtite Co. offers you a complete sales engineering service—experienced men who are always available to study your refractory problems and consult with your engineering, mason and ceramic departments about your specific needs.

For further information, contact your local Ramtite representative or mail the attached coupon.

Ramtite is our business. ...not a sideline.

VENDOR'S COPY

PURCHASE ORDER

FLINN & DREFFEIN ENGINEERING CO.
27 EAST MONROE STREET
CHICAGO 3, ILLINOIS

PURCHASE ORDER NO. 05959

DATE February 10, 1956

VENDOR Ramtite Company

ADDRESS 2563 West 18th Street

CITY Chicago 8, Ill.
ZONE STATE

SHIP TO Flinn & Dreffein Eng. Co.

CARE OF

ADDRESS

CONTRACT NO.

The Ramtite Co.
DIV. OF THE S. OBERMAYER CO.

THE RAMTITE CO., Div. of The S. Obermayer Co.
1813 South Rockwell St., Chicago 8, Ill.

Please send items checked

- ☐ Bulletin on Casting and Gunning Rerfactories
- ☐ Steel Plant Bulletin

Company Name

Attn. Mr. Title

Address

City Zone State

© 1957 This is another in a series of advertisements depicting ways Ramtite Refractories serve the steel industry.

The floor charging machine at left is loading an ingot into a heating furnace. At right is the control panel with ***ElectroniK*** strip chart program controllers.

ElectroniK program controllers automatically regulate soaking and cooling furnaces. These furnaces are also equipped with Honeywell multiple burner ***Protectoglo*** flame safeguard systems. The control cabinet of one of these systems is shown at upper right.

These ***ElectroniK*** program controllers automatically regulate the heating furnace time-temperature program. The panel also contains two Brown indicating pressure controllers which regulate furnace draft.

Program your time-temperature cycles...

with *ElectroniK* controllers

A large eastern producer of specialty steels uses Honeywell *ElectroniK* program controllers for automatic control of heating and soaking furnaces. These controllers have the flexibility needed for the variety of work handled—stainless and heat-resisting steels, matched tool and die steels, high nickel alloy steels, and special purpose alloys.

In the press shop, where a hydraulic press reduces ingots for rolling, *ElectroniK* strip chart program controllers automatically regulate four heating furnaces and two soaking furnaces. These instruments are ideal for this type of operation because their control point settings, and heating, soaking and cooling rates are easily changed to meet the time-temperature requirements of various kinds of stock.

Where a process calls for *repetition* of a prescribed time-temperature pattern, *ElectroniK* circular chart cam program controllers are used to advantage. Once the program is cut on the plastic cam, it can be repeated over and over again with consistent accuracy.

For time-temperature program instrumentation matched to your own particular requirements, call your nearby Honeywell sales engineer. He's as near as your phone.

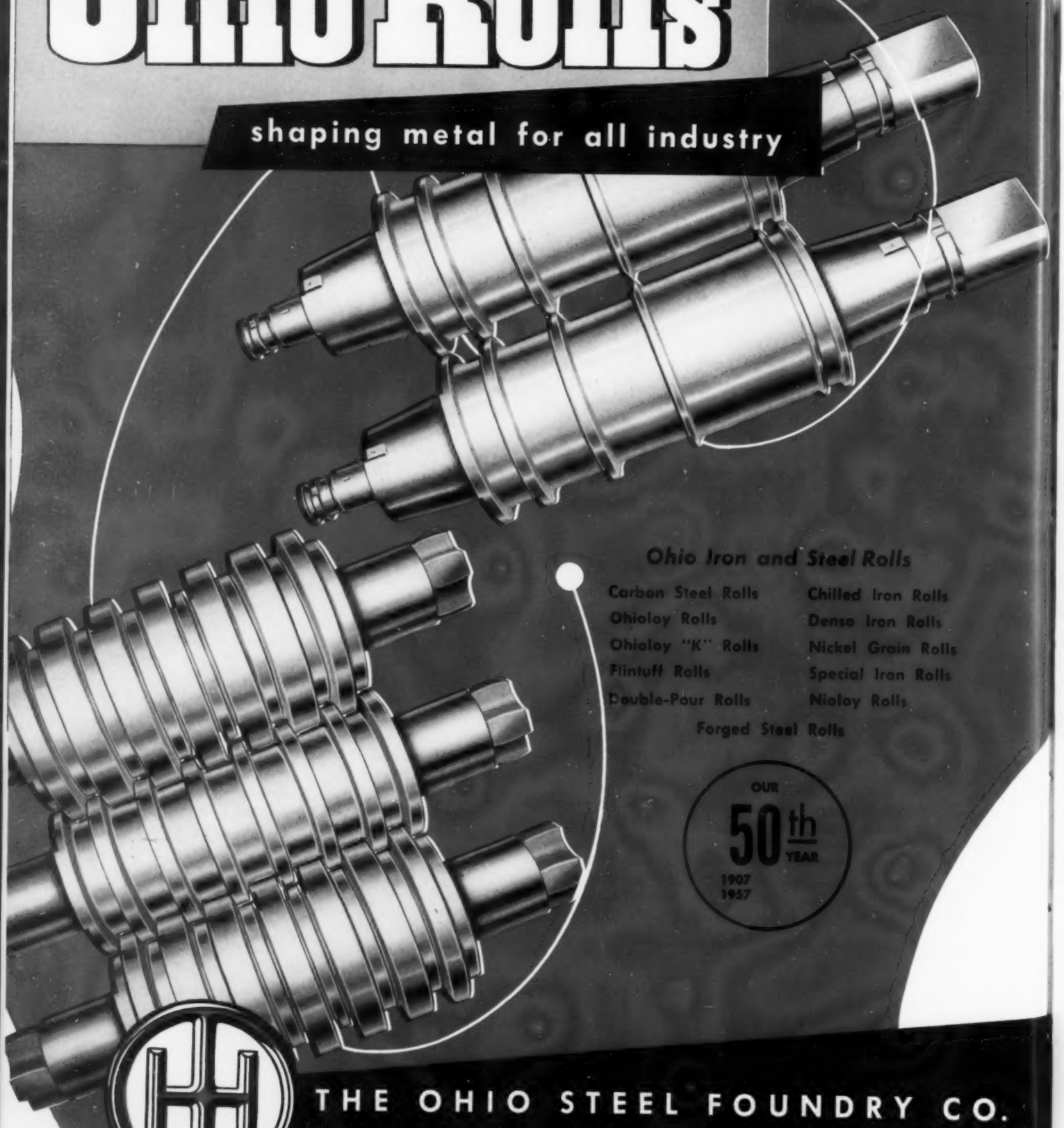
MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Aves., Phila. 44, Pa.—in Canada, Toronto 17, Ont.

• **REFERENCE DATA:** Write for Catalog 1531, "*ElectroniK* Controllers."

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

Ohio Rolls

shaping metal for all industry



Ohio Iron and Steel Rolls

Carbon Steel Rolls	Chilled Iron Rolls
Ohioloy Rolls	Denso Iron Rolls
Ohioloy "K" Rolls	Nickel Grain Rolls
Flintuff Rolls	Special Iron Rolls
Double-Pour Rolls	Nioloy Rolls
Forged Steel Rolls	

OUR 50th YEAR
1907
1957

THE OHIO STEEL FOUNDRY CO.
LIMA, OHIO

Plants at Lima and Springfield, Ohio

ORS

Industry News...

LUKENS STEEL ANNOUNCES $33,000,000 EXPANSION PROGRAM TO BOOST ANNUAL CAPACITY 25 PER CENT

▲ A $33 million expansion program, the biggest in its history, has been announced by Lukens Steel Co. It will boost Lukens' rated ingot capacity by nearly 25 per cent—from 750,000 tons to more than 925,000 tons annually.

Major facilities to be included in the expansion are a new 100-ton electric furnace, new ingot and slab soaking pits, and a new four-high 140-in. breakdown mill to serve Lukens' 140-in. and 206-in. finishing mills, the latter rolling the largest steel plates in the world.

United Engineers and Constructors, Inc., has been awarded the contract for engineering and construction work. Lukens planning and engineering staffs will direct the contractors, and the two companies will work together in the preparation of engineering drawings, selection and purchase of all materials, equipment, supplies, and services, and in the actual construction of facilities. Construction is scheduled to be completed within two years.

At the same time it was also announced that contracts have been awarded for the construction of a $1 million physical testing laboratory. The laboratory is scheduled for full operation within 12 months. Upon completion, it will be fully equipped with the latest devices for testing the hardness, toughness, strength, elasticity, and internal quality of alloy and alloy-clad steel plates.

ANNOUNCE FORMATION OF ORE REDUCTION FIRM

▲ Republic Steel Corp. and National Lead Co. have announced the formation of R-N Corp.

The organization, owned jointly by the two companies, has developed a direct reduction process for the treatment of low-grade and high-grade iron ores, which will provide the steel industry with high-metallic iron feed materials for use in blast furnaces, electric, open hearth and cupola furnaces.

The R-N process was originally devised by National Lead Co. in the course of research and development work on the separation of iron and titanium from titaniferous ores. National Lead and Republic Steel have joined hands as a mutual development team to conduct research work on iron ores. A pilot plant, constructed in 1954 at Republic's Spaulding mine near Birmingham, Ala., has been producing high-metallic iron stock in quantities sufficient for commercial testing purposes.

The high-grade products for open hearth, electric or cupola furnace feed are prepared in briquets weighing from 5 to 25 lb. The blast furnace grade is produced as conventional peach-seed briquets. However, if desirable, larger briquets may be produced.

Principal advantages of the R-N process are:

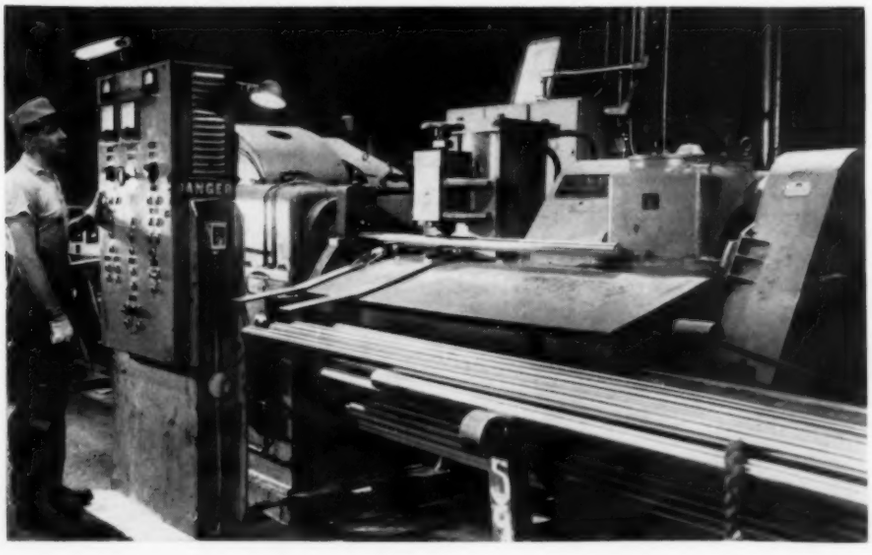
(1) It treats a wide range of both nonmagnetic and magnetic iron ores, yielding high metallic iron content product of uniform composition, low in impurity;

(2) Ready, available, low-grade, solid carbonaceous fuels may be used, regardless of coking properties or sulphur content; and

(3) Phosphorus contained in original ore is largely rejected.

REMOVES DECARBURIZED SURFACES FROM BARS

Recent addition to the cold finishing department of an Eastern specialty steel mill is this high-speed centerless bar turner, capable of turning at speeds up to 12 fpm, with as much as ¼-in. metal removal. Used to remove decarburized surfaces from bars, the Blaw-Knox-Medart type RFPD machine is designed for either carbide or oxide cutting tools. Bars in the as-turned condition are shipped direct to the customer or are finished on a centerless grinder or polished on a two-roll straightening and polishing machine.

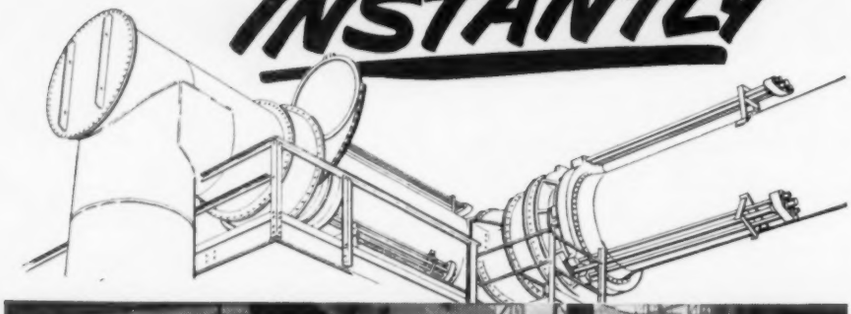


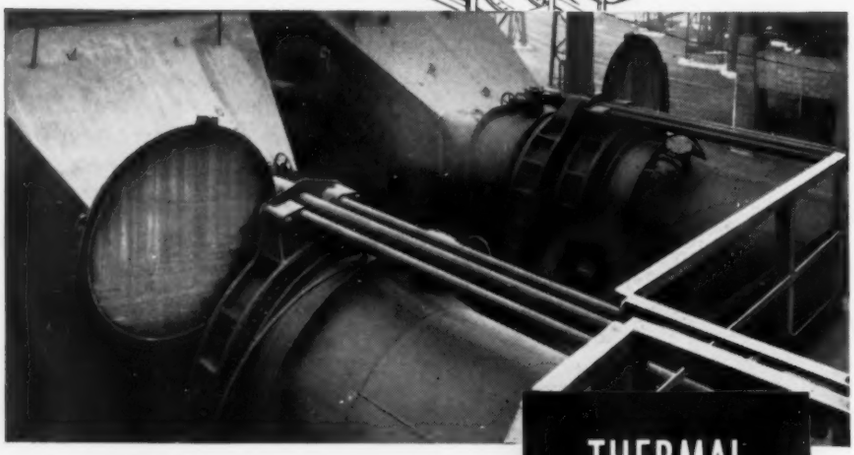
TO BUILD GAS TURBINE BLAST FURNACE BLOWER

▲ The first gas turbine blowing system to be used by America's basic steel industry for supplying air in blast furnace operations, will be built by Westinghouse Electric Corp. for U. S. Steel Corp.'s South Works. The system will be capable of supplying 125,000 cu ft of air per minute.

More than five years of research went into the project to determine advantages of the new system in comparison with conventional systems now in use. Research data show that not only will the initial cost of the gas turbine system be lower, but that operating and maintenance expenses should be less. The gas turbine system requires less

HOW TO CLOSE LARGE GAS MAINS INSTANTLY





Bailey ENGINEERS

THERMAL EXPANSION GOGGLE VALVES

Bailey Mechanical Goggle Valves are produced in diameters from 6" to 72".

A powerful, completely dependable force of nature—the linear expansion and contraction of steel—is used to open and close gas mains equipped with these valves. When steam is applied to three sets of tubes they expand to separate the flanges, thereby freeing goggle plate for swinging to open or closed position.

Designed to protect men and equipment, Bailey Goggle Valves are safe and efficient on gas washers, blast furnace mains, precipitators and boiler plants. Diameters range from 36" to 120".

WILLIAM M. Bailey COMPANY
ENGINEERS
LEADERSHIP THROUGH QUALITY
1221 BANKSVILLE ROAD PITTSBURGH 16, PA

space and uses practically no water.

Steel mill blast furnaces currently use systems in which combustible gas from the furnace is drawn off and used to fire steam boilers. The steam drives a turbine which powers a centrifugal compressor supplying air to the furnace.

The new system will eliminate the need for a boiler and its auxiliary equipment. The blast furnace gas is used to power the turbine which drives an axial flow compressor. The compressor is capable of supplying air to the furnaces at 35 lb per sq in. pressure. It also supplies combustion air for the turbine at the same pressure while a fuel compressor compresses the gas.

The equipment for South Works is scheduled for delivery in 1958.

J & L ACQUIRES ROTARY ELECTRIC STEEL CORP.

▲ At the 35th Annual meeting of the stockholders of the Jones & Laughlin Steel Corp. on April 25, 1957, favorable action was taken to increase the number of shares of common stock to 10,000,000.

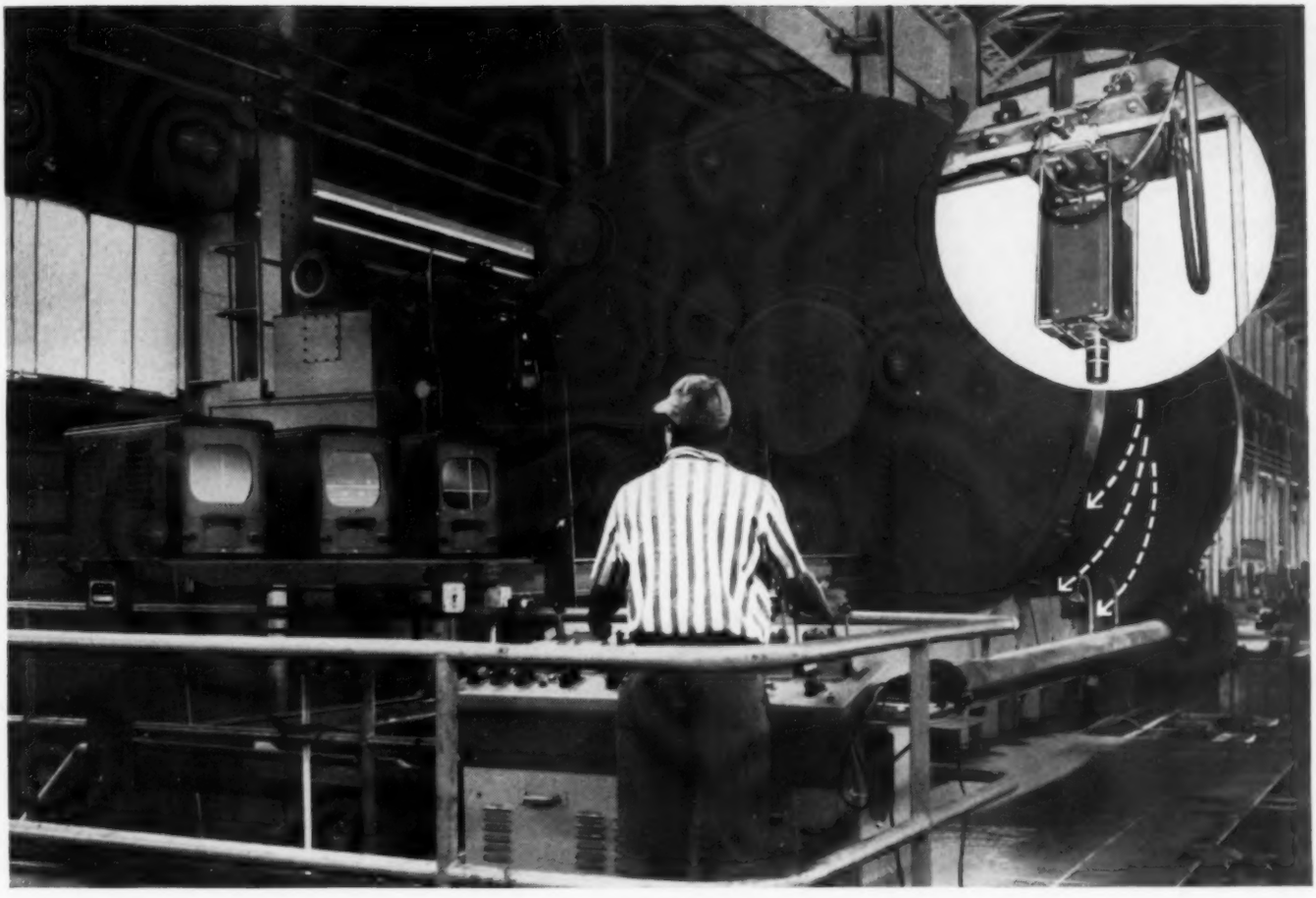
This was done to permit Jones & Laughlin to transfer all the assets and business of the Rotary Electric Steel Corp. to the Jones & Laughlin Steel Corp., thus putting J & L into the stainless steel market.

KAISER STEEL ADDS TO EXPANSION PROGRAM

▲ An additional $81,000,000 has been added to Kaiser Steel Corp.'s current expansion program, according to an announcement by Jack L. Ashby, vice president and general manager.

The entire program, which now totals $194,000,000 will increase Kaiser's ingot capacity from 1,536,000 tons to approximately 3,000,000 tons annually. In terms of finished products the principal increases will be in plate, sheet, tin plate and pipe—products which are in greatest demand in the West.

Major new facilities now under construction at Fontana under the original $113,000,000 expansion include: Two oxygen steelmaking furnaces; eight additional soaking pits; a new universal slabbing mill; a new independent hot strip mill;



How to see where you can't be . . . with RCA Industrial Television!

With RCA Industrial TV to guide him, one man at Lukens Steel Company controls this huge 800-ton plate shear although he cannot see the actual operation! Three RCA TV cameras installed above the blade are connected to three monitors located at the control position. Watching the monitors, the operator moves heavy plate into the shear, lines up the plate with a guide wire, and accurately trims it to size . . . all by remote control!

Wherever it is used, RCA Industrial TV has proved an outstanding factor in personnel safety, increased production, time and material savings. In power plants, factories, laboratories . . . wherever control of vital instruments, processes or materials is required . . . it can be counted on for reliable, accurate performance. RCA Industrial TV is designed and produced to exacting standards by the world leader in electronics.

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COMPANY _____

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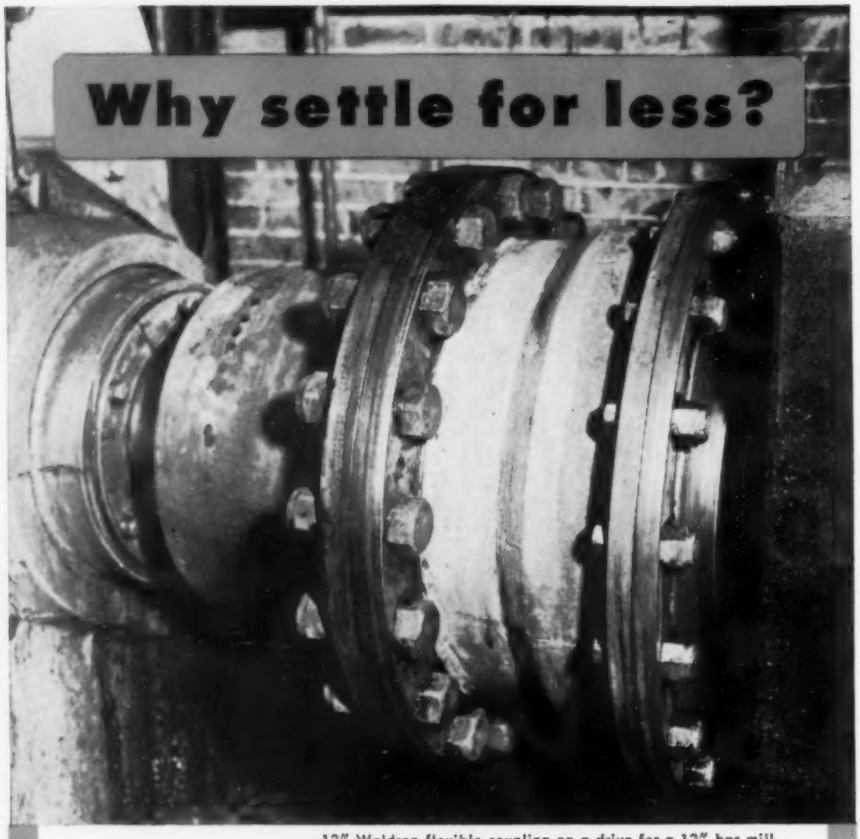
☐ Have representative call.



12" Waldron flexible coupling on a drive for a 12" bar mill.

by specifying

WALDRON

Gear Couplings

you get

STRENGTH —Hubs and cover sleeves for sizes 1¼A through 7A are machined from tough steel forgings. Hubs are keyed to the shafts. The two one-piece cover sleeves function as a single, rigid unit serving as a floating connecting link between the hubs. High strength of forgings makes possible a very compact coupling with low rotating inertia.

RELIABILITY —There are no flexible parts to bend or break and the coupling is dust, moisture, and oil tight. Patented Walflex seal is positioned where centrifugal force is least. Clearance between teeth in hubs and sleeve is engineered so that an oil wedge always separates them, taking the wear.

SERVICE —Plenty of rough bore couplings, already assembled—on the shelf for *immediate* delivery. Finish bored standard couplings shipped to meet customers' schedules. We are geared up to give you realistic delivery on *any* type of couplings.

▶ Ask for Catalog 57

JOHN **WALDRON** CORP.

NEW BRUNSWICK, NEW JERSEY

Representatives In Principal Cities

and a new electrolytic tin plate line.

The $81,000,000 expansion will add the following major facilities to the program: Ninety new coke ovens increasing the number at Fontana to 315; a second sinter plant; a new blast furnace—the plant's fourth; a third oxygen steelmaking furnace; two additional soaking pits; conversion of the existing 110-in. plate mill into a 144-in. plate mill, to increase plate production and make possible the production of wider steel plate; and improvements at the company's Eagle Mountain, Calif., iron ore mine, and at the Sunnyside, Utah and Raton, N. M., coal mines.

The new blast furnace will increase hot metal production 630,000 tons annually to a total of 2,121,000 tons a year.

Construction on the original $113,000,000 expansion began in June, 1956, and that program is now more than one-third completed. Certain units now under construction will be placed in operation late this year. The entire expansion program is scheduled for completion by the middle of 1958.

COKE OVEN CONTRACT AWARDED TO KOPPERS

▲ A battery of 45 coke ovens will be designed and erected at Hamilton Works, Dominion Foundries and Steel, Ltd., by Koppers Co., Inc.

When completed and put into operation the battery will increase the Canadian firm's coke making capacity by 75 per cent. The new ovens will have a capacity to carbonize 1045 net tons of coal per day. Under terms of the contract, Koppers also will install equipment extending the coke handling and coal preparation systems.

Field work on the new battery has already started. Construction work is expected to be completed the early part of next year.

REPUBLIC FLOW METERS ACQUIRED BY ROCKWELL

▲ The assets of Republic Flow Meters Co. of Chicago, Ill., have been acquired by Rockwell Manufacturing Co.

Republic manufactures electronic and pneumatic instruments and process control equipment for the

automatic measurement and control of flow.

Present management of Republic will remain unchanged, with James D. Cunningham, founder of the company, continuing as president. W. F. Crawford, president of Edward Valves, Inc., a Rockwell subsidiary, will be associated with the Republic management in Chicago.

ADDS NEW CONVEYOR AND STORAGE AREA

▲ A pallet chain conveyor and coil storage area has been completed at Granite City Steel Co., linking the end of the company's continuous hot rolling mills with the start of its pickle line. The project, part of Granite City's $33,000,000 expansion program, ties in with an increase in the company's cold rolling capacity which will result from improvements this year in its pickle line and its tandem cold strip mill.

The 705-ft-long, 400 hp conveyor can transfer 148,000 lb of steel a minute. It takes over from the plant railroad the job of moving hot rolled coils.

The coils sit on end on top of two parallel rows of four-wheeled pallets, running on tracks. These pallets form endless chains for each of the conveyor's six sections. An automatic hoist at the end lifts each coil about 12 ft up and positions it at the entry of the pickle line.

There is less handling of each coil with the conveyor than there was when the hot rolled coils were moved in railroad gondola cars. Also, the conveyor and storage area will make possible more efficient scheduling of coils of the same width and gage through the pickle line and the tandem cold strip mill.

CUBAN MILL TO UTILIZE WESTINGHOUSE DRIVES

▲ Electrical drive systems for Cuba's first integrated steel mill—a $12 million plant being built at El Cotorro near Havana—have been ordered from Westinghouse Electric International Co. by the newly-formed Compania Antillana de Acero.

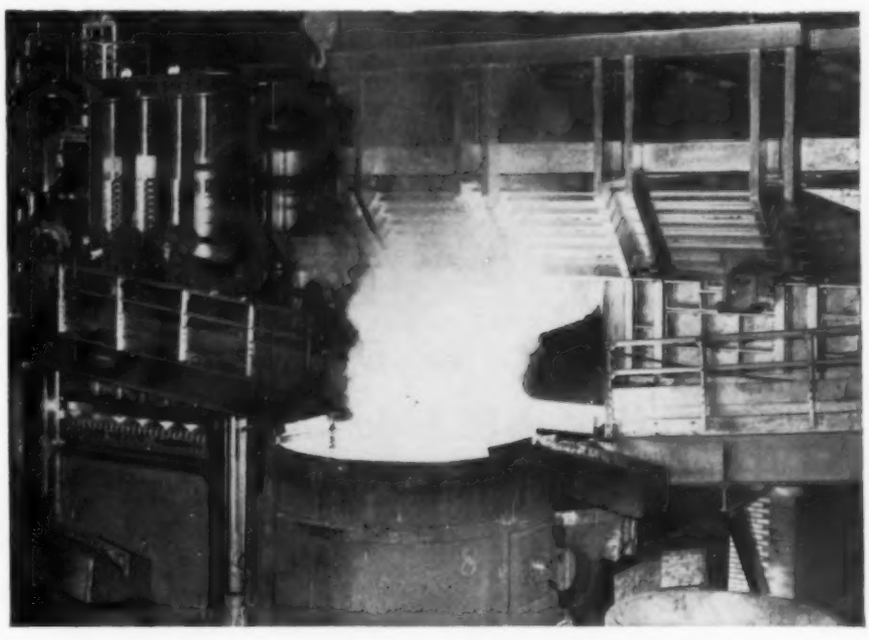
The $800,000 order calls for main drives for a blooming mill, a billet mill and two rolling mills; it includes two 1500-hp motors, a 900/-450-hp two-speed motor and auxiliaries. Motors and controls for the systems will be built at Westinghouse plants in Buffalo, N. Y., and Pittsburgh, Pa. Delivery of the electrical drive equipment is scheduled to be completed in 18 months. Operation of the plant is expected within two years.

Primary production of the plant will be devoted to corrugated bars for use in reinforced concrete construction. Antillana expects to turn out 72,000 tons of bars yearly and will supply 36,000 tons of billets annually to be furnished by Cuba's only other steel mill, Cabillas Cubanas, S. A.

WILL BUILD TWO COKE BATTERIES FOR KAISER

▲ Kaiser Engineers have awarded Koppers Co., Inc., a contract to design and build two new coke oven batteries and to make extensions to the coal chemical plant at the Kaiser

(*Plase turn to page 186*)



Another LOFTUS-Designed Open Hearth Furnace for Portsmouth Division, Detroit Steel Corp.

Detroit Steel Corporation recently tapped the first heat from a new 275-ton open hearth furnace at its Portsmouth, Ohio plant. This is the fifth Loftus furnace installed in this plant since 1952.

The new furnace, which is larger than the original four, is also equipped with full automatic control.

Two pass checkers have been incorporated in the design—a feature that has proved unusually successful on the other Loftus furnaces at this plant. The checker arrangement is unique in that lancing is facilitated for the full depth of the settings in both passes. This was accomplished by extending the charging floor posts to the lower pad level throughout the building, thus providing substantial access to both sides of all regenerators.

It is predicted that the performance of this new furnace will excel even the record of the original four units, which already boast one of the lowest fuel rates in the industry.

We'd like to talk to you about your requirements—without obligation. Write us today.

LOFTUS *Engineering Corporation*

57.7.3A

1 Gateway Center, Pittsburgh, Pa.
140 S. Dearborn St., Chicago, Ill.

6000-TPH BELT CONVEYOR provides continuous handling of raw materials from ships to storage or screen house—performs a job deemed impossible with conventional transportation. Materials discharge from apron feeder to this 60-in. wide, 1260-ft. long conveyor on first leg of mile-long journey. System works year-round—in all weather.

How LINK-BELT developments in materials handling

stay in step

TRAVELING STACKER stores and blends materials. This 150-ft. radius unit beds materials in shallow windrows the full length of its runway, uniformly spreading materials of irregular composition throughout pile.

SHUTTLE BELT CONVEYOR, fed by "high line" conveyor, distributes coke into blast furnace stock bins. This highly flexible conveyor is reversible —provides low-cost materials distribution.

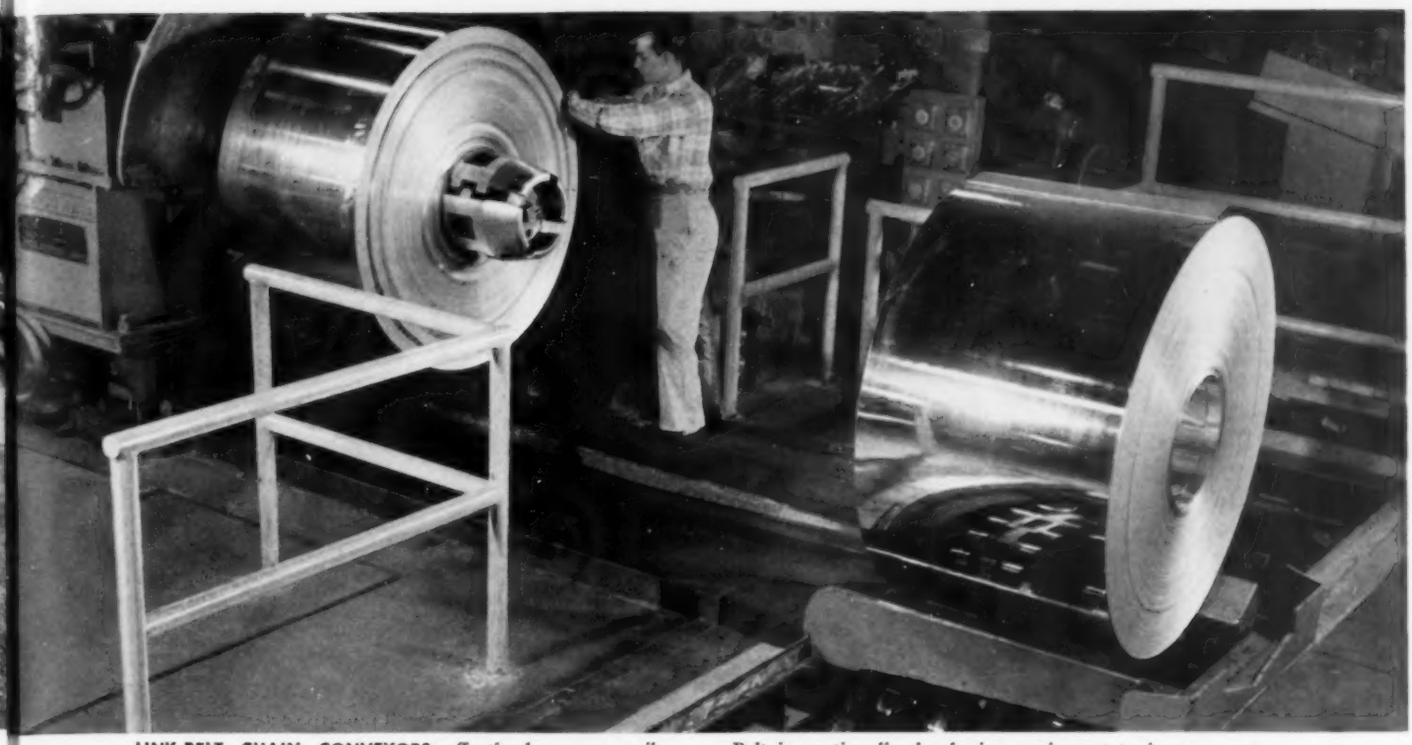
For basic raw materials— bulk handling equipment to keep pace with modern burdening techniques

TODAY'S blast furnace burdening techniques require higher tonnages of raw materials, more extensive storage areas and separate stockpiles for a greater number of ores. In furnishing complete, high-capacity handling systems for both new and expanding mills, Link-Belt helps avoid and relieve problems of storing and reclaiming ores, coke, stone, pellets and sinter.

Regardless of the size or physical layout of your mill, Link-Belt can help you coordinate material flow to fit into new processes . . . meet higher capacities of ship unloading . . . increase production. For facts, call your nearest Link-Belt office. 14,554

LINK-BELT

MATERIALS HANDLING, PROCESSING & POWER TRANSMISSION MACHINERY



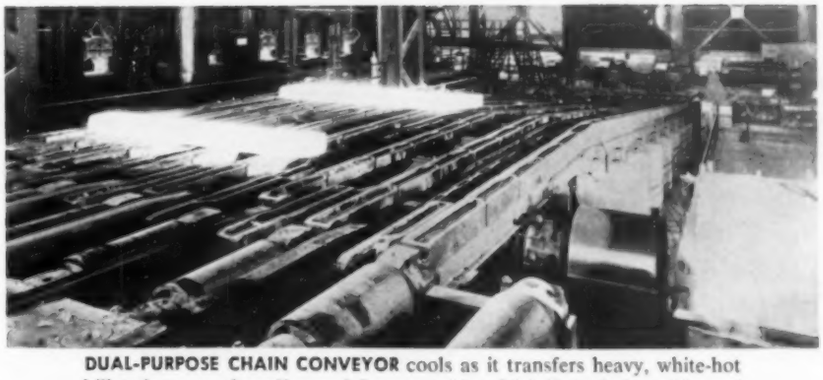
LINK-BELT CHAIN CONVEYORS effortlessly move coils weighing up to 75,000 lbs. Since product handling represents a large proportion of steel production costs, Link-Belt is continually developing equipment to increase output, lower costs and improve safety. Link-Belt offers a full range of conveyors designed to handle all steel products.

with steel demand

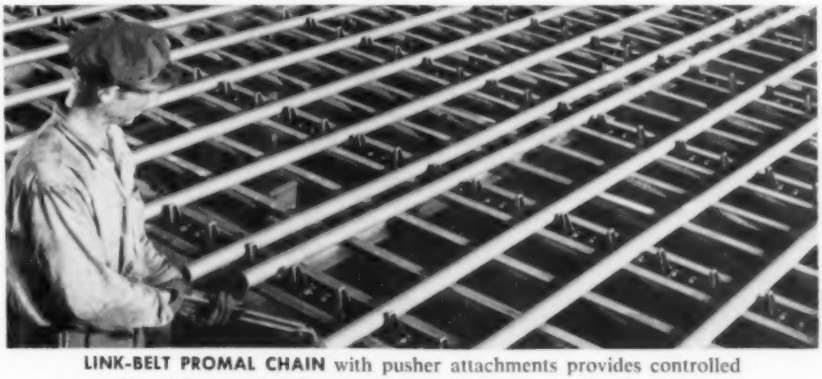
For steel in every form—conveyors to cut handling costs, improve safety, make better use of space

FROM white-hot billets to finished steel products, Link-Belt conveyors help modern mills boost yield, cut waste. Large tonnages are handled dependably, yet gently enough to reduce damage and scrap losses. By limiting crane movements and eliminating travel of vehicles in the vicinity of crews, safety is improved. Other Link-Belt equipment provides effective means for cooling hot products . . . provides active storage . . . permits existing processing equipment to be used to its maximum capacity.

Whether you're planning a new plant or modernizing, get in touch with your nearest Link-Belt office.



DUAL-PURPOSE CHAIN CONVEYOR cools as it transfers heavy, white-hot billets between shear-line and furnace tables. Link-Belt chains withstand continuous heavy loads and severe shock, resist abrasion and corrosion.



LINK-BELT PROMAL CHAIN with pusher attachments provides controlled cooling of longer pipe than previously possible. Conveyor receives tubes directly from furnace—controlled speed permits uniform cooling.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

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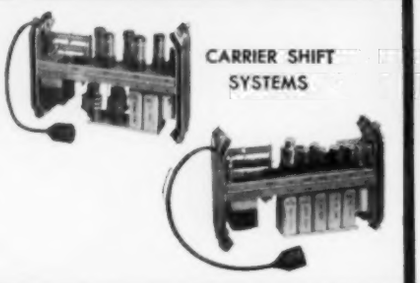
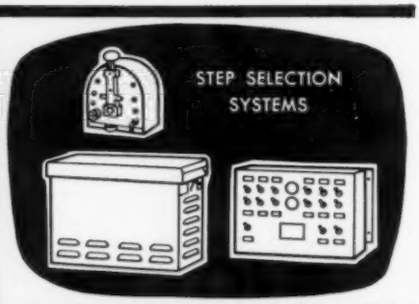
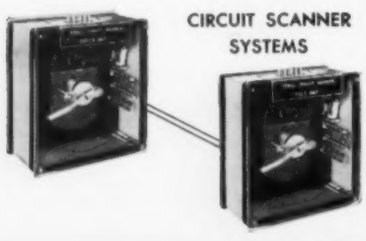
CONTROL SYSTEMS

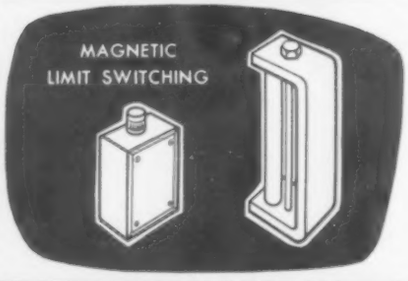
FOR MODERN INDUSTRY

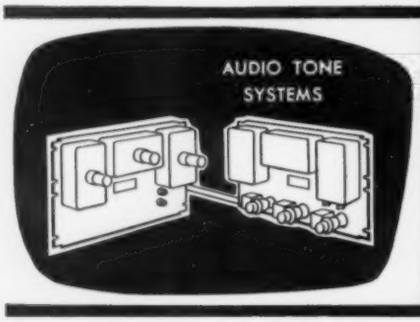
with standard components, we can provide control and indication for many purposes.

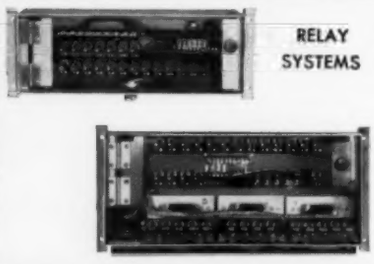

CARRIER SHIFT SYSTEMS


STEP SELECTION SYSTEMS


CIRCUIT SCANNER SYSTEMS


MAGNETIC LIMIT SWITCHING


AUDIO TONE SYSTEMS


RELAY SYSTEMS

Femco Systems use only one pair of wires or operate over existing power lines!
Let a Femco sales engineer help solve your problem.

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COMMUNICATION • Electronic Engineers • AUTOMATION

(*Continued from page 183*)

Steel Corp.'s Fontana, Calif., operations, according to an announcement by Koppers.

In making the announcement, Dr. W. C. Rueckel, vice president and general manager of Koppers Engineering and Construction Division, said that each battery would consist of 45 Koppers-Becker gas gun type ovens. When completed Kaiser Steel's Fontana plant will have a total of seven batteries, each consisting of 45 ovens. The existing five batteries also were designed and built by Koppers. The first ovens were built in 1942. Two were completed in 1952.

The new batteries will have a capacity for carbonizing 1850 tons of coal a day. Total carbonizing capacity of all seven batteries will be 6600 tons of coal a day.

FURNACE CONTRACT AWARDED TO LOFTUS

▲ Innocenti Corp. of Italy has awarded a contract to Loftus Engineering Corp. for the engineering, design, construction, supervision and special equipment for the installation of four basic open hearth furnaces and four 2-hole batteries of ingot heating furnaces to be built in Venezuela.

Capacity of the furnaces is 250 metric tons each. They are of the stationary type and are to be fired with either oil or a combination of gas and fuel oil. The furnaces will be equipped with fully automatic reversal control.

Each of the eight holes of ingot heating furnaces will have a holding capacity of about 125 metric tons, based on 30 in. x 30 in. x 87 in. ingots. The holes will be approximately 20 ft-0 in. long, 15 ft-0 in. wide and 13-ft-0 in. deep. The control system for these pits will be fully automatic for normal operation with provision for manual control when desired. These furnaces will be equipped with integrated recuperation and with fully automatic temperature, combustion and pressure controls.

ADD LADLE FEEDERS AT CAMPBELL WORKS

▲ Eleven new ladle additions feeders are being added to the Campbell Works of Youngstown

VAUGHN®
MOTOBLOX®

The PRE-WIRED PACKAGE

for HIGHER SPEEDS
for GREATER FLEXIBILITY
for INCREASED STABILITY

"Quick on the Draw" has a new meaning with the pre-wired, packaged MOTOBLOX: higher top speeds in regular operation! Add to this the advantages of new stability, new flexibility, new low installation costs, new accessibility of electrical equipment—and you get *payoff* performance that pays looking into. *Write us.*

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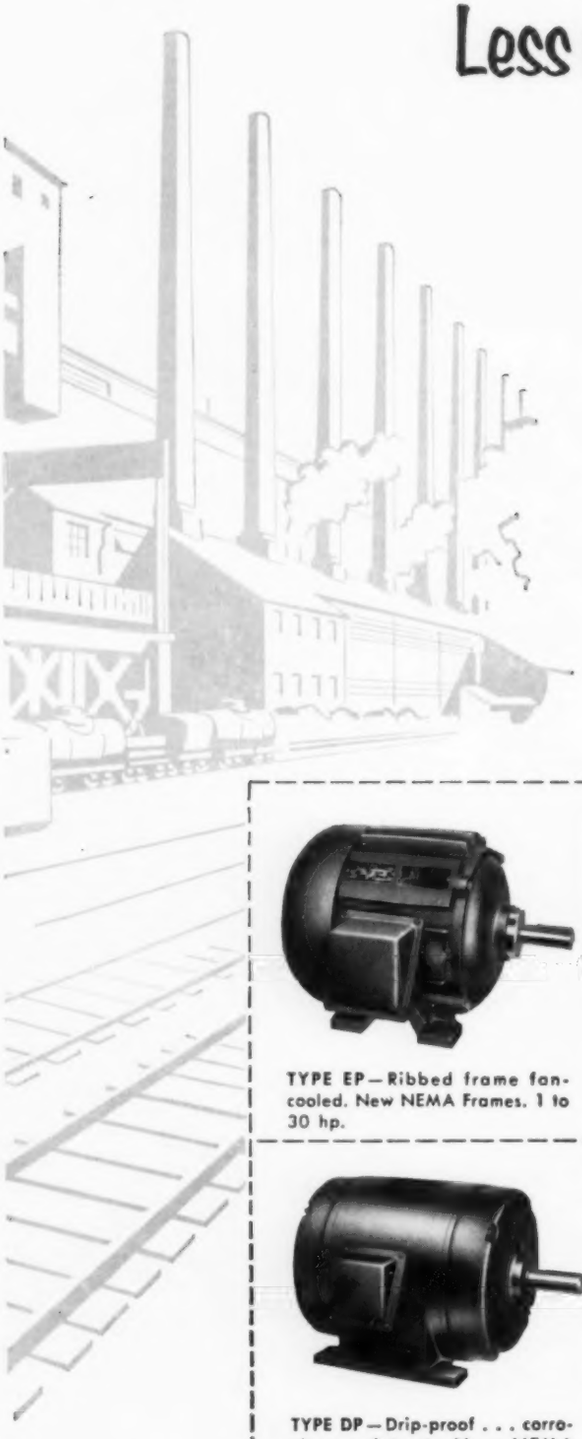
COMPLETE COLD DRAWING EQUIPMENT—Continuous or Single Hole . . . for the Largest Bars and Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys

WAGNER ELECTRIC MOTORS . . . THE CHOICE OF LEADERS IN INDUSTRY



Less down time...lower upkeep...

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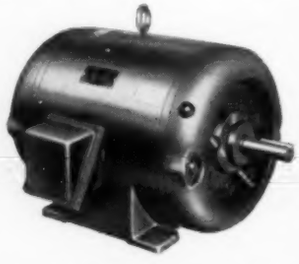
Wagner Protected Type Industrial Motors

Wagner protected type motors lower your maintenance costs . . . cut down time, because they are designed for use where operating conditions demand EXTRA protection—for bearings or windings, against corrosive vapors or abrasive dirt, in explosive atmospheres or exposed outdoor locations.

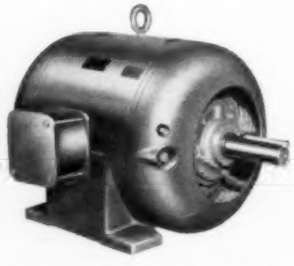
Each of these Wagner Motors will give completely dependable performance in its specific application—with a minimum of maintenance. All these motors can be relubricated, when necessary, for longer bearing life.

A Wagner field engineer, expert on motor applications, will be glad to help you choose the *right* motors for your specialized needs. Just call the nearest of our 32 branch offices, or write us for Bulletins on Wagner Industrial Motors.

TYPE EP—Ribbed frame fan-cooled. New NEMA Frames. 1 to 30 hp.



TYPE EP—Totally-enclosed fan-cooled. Corrosion-resistant frames. 40 to 250 hp.



TYPE JP—Fan-cooled . . . Explosion-proof. Cast iron frames. 40 to 250 hp.

TYPE DP—Drip-proof . . . corrosion-resistant. New NEMA Frames. 1 to 30 hp.

TYPE DP—Drip-proof. Cast iron frames. 40 to 125 hp.

TYPE RP—Drip-proof. Fabricated steel frames. 125 to 500 hp.

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ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

Sheet & Tube Co., following a year of operation of the first such feeder to be built and supplied by the Blaw-Knox Co.

The machine is designed to make ferro-manganese additions to the ladle rather than to the bath, resulting in substantial economies according to test data. When the new machines are installed at Youngstown, all 12 of the open hearths will be equipped.

The feeder was developed by A. J. Boynton and Co. of Chicago for the Lone Star Steel Co., where according to the users, the feeder produced an average saving of 15 cents per ton of ingots produced. According to Blaw-Knox, success of the new feeder was first established at Lone Star where production required an addition of from 28 to 30 lb per ton of ingots of 80 per cent ferro-manganese.

Experience at Lone Star from over 2000 heats indicates that up to 31.5 lb of ferro-manganese per ton of ingots can be added successfully to the ladle.

Economies result, according to test data, because 10 per cent more manganese is recovered when additions are made to the ladle rather than to the furnace. After producing a steel with an analysis more rigid than that required by the American Iron and Steel Institute standards, Lone Star recovered 85.3 per cent of the manganese as compared with 75.3 normally recovered when additions were made to the open hearth. Further savings are possible because control of feed and placement permits a narrower manganese specification.

This new machine, now being manufactured by the Steel Plant Equipment Department of Blaw-Knox, consists of a hopper, hopper loader, electrical vibrating feeder and chute. Especially designed to the operating conditions of the open hearth shop in which it will be used, the unit will feed manganese at a controlled rate and to the correct location.

A feature built into the 11 new feeders for Youngstown Sheet & Tube is a self-dumping mechanism. In case of electrical power failure while tapping a heat, an air cylinder tilts the manganese hopper delivering ore to a chute where it flows by gravity into the ladle. The hopper loader is also air operated.

Additions are started normally when the ladle is approximately 20 per cent full and stopped when 80 per cent full. The rate of feed is adjusted manually by turning a small hand wheel on the control panel. Rate of addition varies from up to 10,000 lb of manganese in 3 min to 3000 lb in 20 min or longer.

Conversion to this practice of adding manganese to the ladle is expected to be complete when the feeders will be put into service at Youngstown Sheet & Tube this summer.

H. K. PORTER ACQUIRES ELECTRICAL CONCERN

▲ The acquisition of R. Thomas & Sons Co., Inc., manufacturers of high voltage and other electrical porcelain, in Lisbon, Ohio, was announced by H. K. Porter Co., Inc. The Thomas operation will be combined with Porter's Delta-Star Electric Division. This is the second acquisition in the electrical manufacturing field for Porter during the past few weeks; on April 23rd Federal Wire and Cable Co., Ltd. of Guelph, Ontario, was acquired.

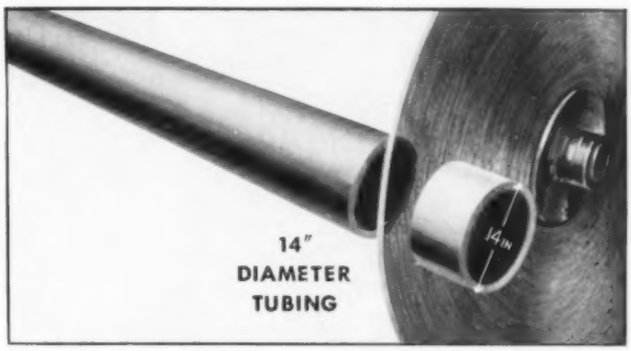
R. Thomas & Sons Co., Inc. also manufactures electrical porcelain used in connection with transmission lines, outdoor substations, and specialty porcelain used by electrical equipment manufacturers. Sales for the Thomas Works, as it will be known, are to be combined with the national sales organization of Delta-Star.

Allison
Abrasive Cutting Wheels

Abrasive Cutting Know-How

Know-How is just as vital to top performance in abrasive cutting as in any other machine tool operation

BETTER TUBING CUT-OFFS UP TO 14" DIAMETER



• The fastest, lowest-cost, highest-quality cut-offs of almost any tubing material, *in sizes up to 14" diameter*, can be obtained by abrasive cutting...with absolute minimum of burr.

But such performance on your individual tube-cutting job is dependent on your use of the particular type and grade of abrasive wheel that provides the best balance for such inevitable variables as...available equipment...material to be cut ...cutting speed...desired quality of cut...and finally, wheel life.

The full line of Allison Wheels ...rubber or resinoid bonded for wet or dry cut...includes many wheels that are especially designed for Tube Cutting Service.

Allison Field Men...all of them Abrasive Cutting Specialists...have the specialized Know-How, and the wheels, to help you arrive at the best answers to your specific problems. Please ask for their help, without obligation.

Abrasive Cut-Off is the Ideal Method for tubing...tool rooms... job shops...high temperature alloys and tough titanium...heat-sensitive metals...solids up to 12" billets and many other jobs.

***For more complete information** write for this helpful booklet —*
ABRASIVE CUTTING BY ALLISON

ACCO

Allison Division • AMERICAN CHAIN & CABLE

254-G Island Brook Avenue, Bridgeport 8, Conn.

"...the most return, dollar for dollar, on our investment"

says RALPH SCULLY, Plant Engineer,
Grinnell Corporation, Cranston, R.I.

Pangborn Continuous-Flo® Barrels pay for themselves in short time at Grinnell

In the manufacture of its quality pipe fittings and pipe hangers, Grinnell Corporation cleans thousands of castings daily in its foundries at Cranston, R.I., and Columbia, Pa. To do this effectively and economically proved a problem. "We investigated all types of cleaning equipment," says Mr. Scully, "and decided the Pangborn Continuous-Flo Barrel lent itself best to our production situation and would give us the most return, dollar for dollar, on our investment. We installed Continuous-Flo Barrels and have been pleased with their performance. Based on continuous operation, cost savings indicate they will pay for themselves in a relatively short time."

If you have an unusual cleaning problem, Pangborn offers a special service. Pangborn engineers will study your problem and its relation to your production line. Then they will design a machine for your particular needs. Find out now how Pangborn's engineering service can give you better cleaning and faster production at lower cost.

Write today for Bulletin 1210 to PANGBORN CORP., 4400 Pangborn Blvd., Hagerstown, Maryland. *Manufacturers of Blast Cleaning and Dust Control Equipment.*

Pangborn blast cleans cheaper

CUTS COSTLY SUNDAY MAINTENANCE

Revolutionary P&H development . . . Electronic "stepless" crane control . . . eliminates 60% of wearing parts

Maintaining your cranes on Sunday to avoid production-line interruptions during the week is expensive, isn't it? P&H electronic crane control is the answer to that problem.

P&H electronic crane control is an outstanding new crane development, exclusive with Harnischfeger, and proved in over 300 installations. It's a simple wiring circuit that eliminates over 60% of the wearing parts found on previous crane controls — the wearing parts that need most frequent replacement.

Electronic control not only reduces maintenance, it furnishes "stepless" control response, making possible infinitely variable—more sensitive—crane operation. What's more, this major improvement can be applied to any existing AC crane.

Make sure your next overhead crane inquiry specifies this revolutionary crane development — P&H Electronic Control. Write Dept. 107G, Harnischfeger Corporation, Milwaukee 46, Wisconsin.

HARNISCHFEGER

P&H INDUSTRIAL DIVISION

MILWAUKEE 46, WISCONSIN

Westinghouse-equipped

20-ton crane built to work 60 minutes every hour

moving skelp loads at Jones & Laughlin's modern new tube mill

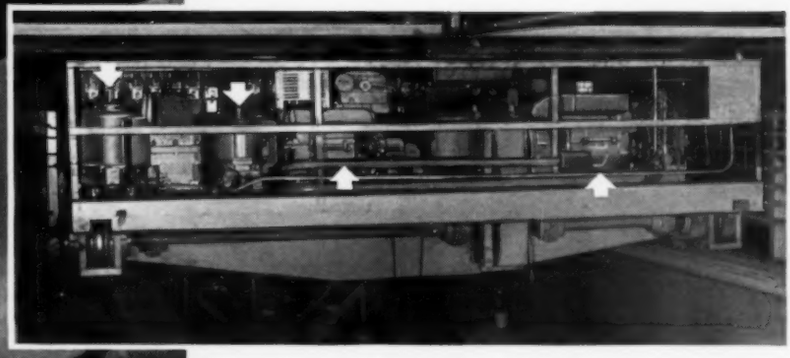
Outfitted with a C-hook, this new Movable Bridge Crane handles 9,250-pound coils of welded tube skelp, two at a time, in almost constant duty. Westinghouse silicone-insulated mill motors, fast-acting crane control and brakes are fully coordinated to give this unit the rugged stamina and positioning accuracy for continuous handling of big loads.

The low-inertia armature of the 600 Type MC mill motor assures quick response. Outstanding hoist control features an armature shunt point for light hook speed, *plus* an anti-cycling relay to prevent pumping in or out of the limit switch zone. Exclusive Westinghouse self-adjusting d-c magnetic brakes are used to assure positive braking when handling heavy loads. Westinghouse years of experience and engineering leadership have developed the industry's finest and most complete line of motors and controls for heavy-duty mill crane and hoist applications.

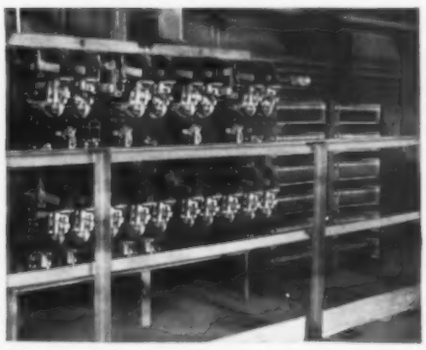
For all the facts, call your local Westinghouse sales engineer or write Westinghouse Electric Corporation, P. O. Box 868, 3 Gateway Center, Pittsburgh 30, Pennsylvania. J-22029

YOU CAN BE SURE...IF IT'S

Westinghouse



Crane is equipped with Westinghouse d-c mill motors to power bridge and trolley as well as the 20-ton main hoist and auxiliary 5-ton hook. Westinghouse SA brakes are completely self-adjusting—no adjustment or maintenance is ever necessary with wear.



Westinghouse Type M d-c contactors and AZ relays assure millions of trouble-free make-breaks for dependable service in continuous steel mill duty. Self-cleaning, knife-edge bearings guard against dust and dirt.

This Adams CYCLONE Saves You MONEY!

The Aftercooler and Separator that assures

DRIER Compressed Air

Here's real teamwork! First, the Adams Aftercooler brings the compressed air temperature down — within 10° of the cooling water — where it holds almost 40% less moisture than air from conventional units.

Then, the Adams Separator creates a cyclone to efficiently remove the condensate . . . giving you cooler, drier air for your system.

Thousands in use throughout industry. It will pay you to find out all the details. Mail the coupon below today.

R. P. ADAMS CO., Inc.

Buffalo 17, New York

R. P. ADAMS CO., INC. Ma-57
223 East Park Drive
Buffalo 17, N. Y.

Please send my FREE copy of Bulletin #711 on Adams Cyclone Separators and Aftercoolers.

Name..... Firm.....

Street..... City..... State.....

Pulpit in plant of Granite City Steel Corporation, Granite City, Ill., air conditioned by Lintern Aire-Rectifier—*Photograph, courtesy of* ***Steelways****, official publication of the American Iron and Steel Institute.*

by Air Conditioning Pulpits — and Crane Cabs — you achieve FULL USE OF CAPITAL EQUIPMENT

The Lintern "Split System" Aire-Rectifier allows for a minimum of space-consuming equipment within the pulpit, provides thoroughly cooled, dehumidified even air distribution throughout the pulpit without costly space-using air ducts.

Condensers are located adjacent to the pulpit, connected to the cooling coils within the pulpit by small, easily concealed, flexible refrigerant lines. A majority of the parts are interchangeable with Lintern Crane Cab Conditioners, minimizing the number of different spare parts required.

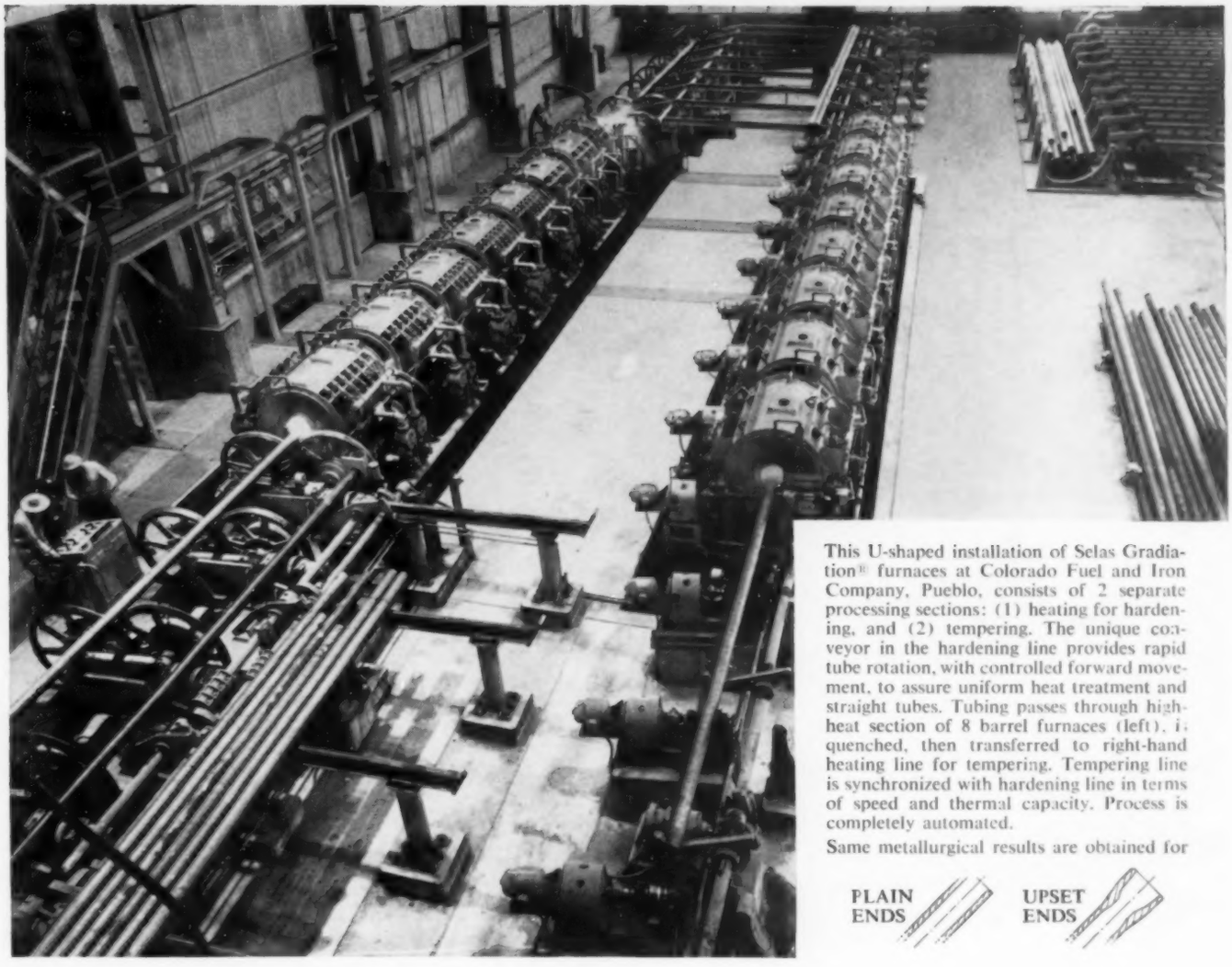
MEN GET MORE DONE

Regardless of ambient temperatures, this Aire-Rectifier provides a constant, uniform temperature of 80° to 85° — winter and summer — and freedom from fumes and gases. It means higher output per man and low labor turnover.

No matter what the temperature — how hot or how cold — the Lintern Aire-Rectifier works efficiently. An absolutely dependable unit, it operates with a minimum of maintenance. *It assures full use of costly capital equipment.*

Ask for new Air Conditioning Bulletin AC-573.

Larco, inc.
DISTRIBUTORS OF LINTERN CORPORATION PRODUCTS
ROUTE 20, EAST • PAINESVILLE, OHIO



This U-shaped installation of Selas Gradiation® furnaces at Colorado Fuel and Iron Company, Pueblo, consists of 2 separate processing sections: (1) heating for hardening, and (2) tempering. The unique conveyor in the hardening line provides rapid tube rotation, with controlled forward movement, to assure uniform heat treatment and straight tubes. Tubing passes through high-heat section of 8 barrel furnaces (left), is quenched, then transferred to right-hand heating line for tempering. Tempering line is synchronized with hardening line in terms of speed and thermal capacity. Process is completely automated.

Same metallurgical results are obtained for

Physical Properties of Deep Well Casing Improved, Uniformity Achieved . . . with Selas Short-cycle Hardening and Tempering

In the heat-treating of carbon and low alloy seamless steel tubing, for a given tensile strength or hardness, Selas short-cycle hardening and tempering develops higher yield strength with no sacrifice in ductility. For with Selas short-cycle heating, a higher tempering temperature can be employed (with no soaking), enabling more complete relief of residual hardening stresses.

Surface carburization is reported to be negligible, scaling is minimized . . . even though no specially-prepared atmosphere is used.

With Selas Gradiation, heating for hardening, quenching and short-cycle tempering of steel tubing are performed continuously, automatically. Consistent metallurgical uniformity is obtained throughout each tube and from tube to tube . . . in both plain and upset ends.

Selas short-cycle heating is used in four of the five lines producing heat-treated oil well casing and Selas barrel furnace lines are widely used throughout the steel industry for annealing as well as hardening and tempering seamless tubes; for heating tubes for sizing; for normalizing welded pipe; for annealing and hardening-and-tempering bars.

All are continuous, in-line operations. Compact, fast-heating, gas-fired Selas furnaces save valuable floor space, are adaptable to variations in production-line speeds.

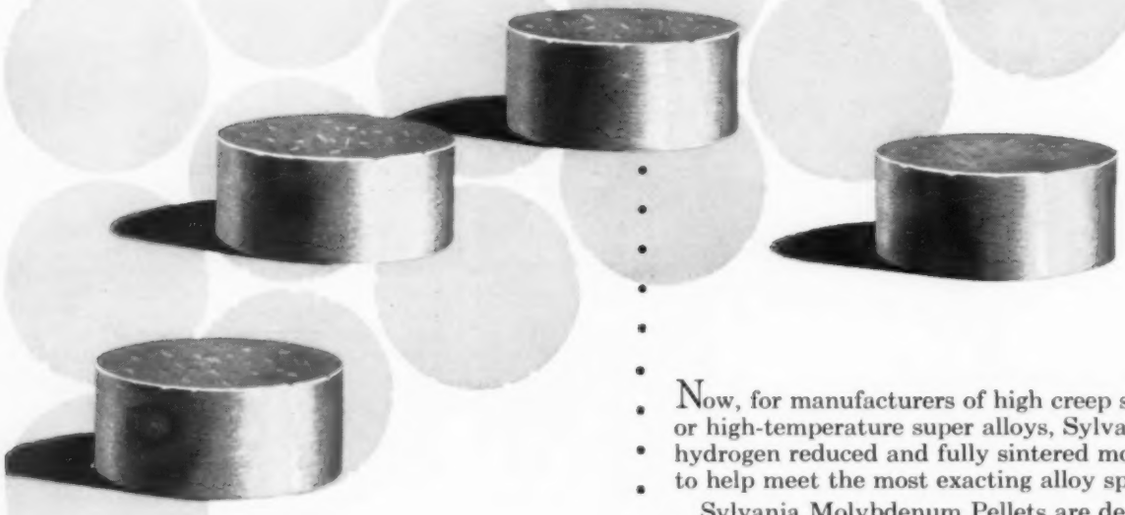
Send for informative articles on Selas tube and bar heating installations. Address Dept. 45.

SELAS
CORPORATION OF AMERICA
DRESHER, PENNSYLVANIA

Heat and Fluid Processing Engineers

DEVELOPMENT • DESIGN • CONSTRUCTION

To help you meet rigid production specifications . . .



Sylvania 99.5% Pure MOLYBDENUM PELLETS

for Super Nickel, Chromium, and Cobalt-base Alloys

Now, for manufacturers of high creep strength alloys or high-temperature super alloys, Sylvania offers hydrogen reduced and fully sintered molybdenum pellets to help meet the most exacting alloy specifications.

Sylvania Molybdenum Pellets are designed specifically for use in vacuum melting operations. They provide a readily available source of molybdenum having a purity of at least 99.5%—typical purity is 99.85%. This constant high purity simplifies the calculation of additions to each melt as the usual variations of purity and gas content are eliminated. By maintaining a high density, the gas content of the pellets is kept well below that acceptable for vacuum melting. In addition, the compact uniform size of the pellets (1″ in diameter by ½″ high) facilitates weighing and charging to the melt.

When you use Sylvania Molybdenum Pellets, you benefit in other ways, too. Their continuous availability means you can plan your production schedules on a long range basis. Further, their pricing stability permits you to price your own product without having to worry about fluctuating raw materials costs.

Your Sylvania sales engineer will be glad to discuss your molybdenum requirements or the high-purity tungsten available in sintered ingot form for vacuum melting. For further information, write to:

SYLVANIA ELECTRIC PRODUCTS INC.
Tungsten and Chemical Division, Towanda, Penna.
TUNGSTEN • MOLYBDENUM • CHEMICALS
PHOSPHORS • SEMICONDUCTORS

SYLVANIA

Lighting • Radio • Electronics • Television • Atomic Energy

Publication Service...

MAY, 1957

(1) Bus Conductor Handbook

The properties and uses of aluminum bus conductors are discussed in a handbook available from Aluminum Co. of America. The handbook presents facts and figures for engineering and maintenance of bus installations. It also contains graphs, tables and photographs. Introductory material traces the development of aluminum's use and its properties as a conductor. Subsequent chapters deal with conductor shapes, design, reactance, capacities, deflections, joints and short-circuit conditions; the final sections explain installation. A comprehensive bibliography refers the user to technical articles available for exploration of related subjects.

(2) Transformer Maintenance

Westinghouse Electric Corp. has available a booklet entitled "Timely Tips on Transformer Maintenance." The booklet discusses transformers and their maintenance and includes such subjects as general inspection procedures, classification of transformers, methods of drying out and transformer connections. (Booklet B-4716-B)

(3) Precipitator Automation

A new bulletin describing the automation system recently announced by Research-Cottrell, Inc. has been made available. The bulletin defines the term "ideal electrical power," and demonstrates by means of comparative charts how this precipitator power level, required for optimum performance, can be much more closely approached by automation than by the manual control now in wide use. Additional benefits of this system, such as lower operating costs and greater utilization of installed electric power, are outlined. Two pages are devoted to a description of how the electronic feedback circuits of this system control precipitator sparking rate, current and voltage. This description is supplemented by a block diagram of the system and a photograph of the servo-control chassis.

You Can Obtain . . .

. . . any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

Note: Post cards expire three months after publication date.

(4) Oil Burners and Coil Heaters

Hauck Manufacturing Co. has published some new catalog data sheets describing their oil burners and electric oil heaters. These data sheets discuss the features of the equipment, including capacity and dimension charts. Advantages and methods of operation are included, as well as cut-away drawings. (Data Sheets Nos. 409-A, 709-B)

(5) Worm Gear Drives

Information on their complete standard line of speed reducers, worm gear sets and special units is available in a bulletin published by Cleveland Worm & Gear Co. The bulletin contains photographs and descriptions of speed reducers, and also describes their helical gear attachments, fan cooled units, worm gear screw jacks, and specialized reducers for custom-design requirements. (Bulletin 145)

(6) Recorders

The Esterline-Angus Co., Inc., has published a bulletin describing their a-c and d-c wattmeters. The bulletin contains illustrations and graphs of these recorders. Individual measuring elements used in these wattmeters are included as well as a discussion of the wattmeter vs. the ammeter. Tables dealing with both the a-c and d-c recorders are also included.

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52	ALLISON DIVISION, AMERICAN CHAIN & CABLE CO.		Abrasive cutting
53	ATLAS CAR & MFG. CO.	BULLETIN 1283	Transfers
54	BABCOCK AND WILCOX CO., THE	BULLETIN R-35	Refractory castables
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56	CHEMICAL CONSTRUCTION CORP.	BULLETIN M-103	Washers
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62	ELECTRIC CONTROLLER & MFG. CO., THE	BULLETIN 6715	Tab-weld resistors
63	ELLIOTT CO.		D-c motors
64	ESTERLINE-ANGUS CO., INC., THE	CATALOG CC854A	Recorders
65	EUCLID ELECTRIC & MFG. CO.	BULLETIN 3004	Heavy-duty resistors
66	FARVAL CORP., THE	BULLETIN 26-S	Centralized lubrication
67	GEAR GRINDING MACHINE CO., THE		Constant velocity universal joints
68	GENERAL ELECTRIC CO.	GEA-5654	Motors
69	GOLDEN-ANDERSON VALVE SPECIALTY CO.	BULLETIN W-7A	Valves
70	HAGAN CHEMICALS & CONTROLS, INC.		Reprint of article on soaking pit installation
71	HAUCK MANUFACTURING CO.	CATALOG 809	Gas burner
72	HERR EQUIPMENT CORP., THE	BULLETIN NO. 561	Complete processing and handling equipment
73	HUNT AND SON, INC., C. B.	BULLETIN NO. 571	Control valves
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78	LINK-BELT CO.	DATA BOOK 2416	Belt idlers
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81	PANGBORN CORP.	BULLETIN 1210	Blast cleaning and dust control equipment
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83	PENNSYLVANIA ENGINEERING CORP.		Major engineering projects
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86	RAMTITE CO., THE		Casting and gunning refractories
87	RELIANCE ELECTRIC AND ENGINEERING CO.	BULLETIN B-2401	Totally protected motor
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IRON & STEEL ENGINEER

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PITTSBURGH 22, PA.

DATA ON VOLMEX 81 ...

HOW VOLMEX® 81

performs as a high volatile ingot mold coating when applied . . .

(1) Wet (2) Dry (3) At varying ingot mold temperatures

VOLMEX 81 is a highly volatile ingot mold coating which has been tested and adopted by a number of steel plants. The charts below are based on actual data obtained during such trial runs. Because of the differing practices employed by various companies, we have included several variables. First, because VOLMEX 81 can be applied either dry or with water as the carrier (spraying, swabbing or dipping are all practical), we have presented test figures on its use, both wet and dry. Second, we have included data on a range of ingot mold temperatures from 100°F. to 700°F., and third, we offer for comparison the results of a one-hour and a three-hour time-at-mold temperatures. No matter what method of application was used, VOLMEX 81 was found to repel metal splashes effectively before they could solidify and cling to the mold wall. At the same time, enough of the graphite-base coating was left at the metal/mold interface to keep the main body of the pour from clinging when it reached the point of splash, thus reducing surface defects. For wet application, VOLMEX 81 is easily stirred into suspension and remains in that state for hours without re-agitation.

VOLMEX 81 is the most volatile of the United States Graphite Company ingot mold washes. Others, in order of their volatility are: 90-B (non-volatile), MEX (very little volatility), and VOLMEX (volatile, but less so than VOLMEX 81). Write us for more extensive details or our engineering staff is available for on-the-spot assistance. Mold spray and mixing equipment are ready for your use in tests you may want to arrange.

Table I **Volatility of VOLMEX 81 Ingot Mold Wash**

Mold Coating Volatility Test—VOLMEX 81 Water Application 2.75 lbs. powder/gal. water—Period—1 Hour at	Temperature 300°F.	500°F.	700°F.
% loss after heating for 1 hour	74.3	73.9	75.4
% loss on ignition at 1900°F. after 1 hour at specified temperature	16.1	14.4	11.3
Total percent volatile matter	90.4	88.3	86.7

Table II

Mold Coating Volatility Test—VOLMEX 81 Dry Application—Period—1 Hour at	Temperature 100°F.	300°F.	500°F.	700°F.
% loss after heating for 1 hour	0.1	0.8	0.9	2.8
% loss on ignition at 1900° F. after 1 hour at specified temperature	60.8	60.4	59.7	56.5
Total percent volatile matter	60.9	61.2	60.6	59.3

Table III

Mold Coating Volatility Test—VOLMEX 81 Dry Application—Period—3 Hours at	Temperature 100°F.	300°F.	500°F.	700°F.
% loss after heating for 3 hours	0.1	0.8	1.1	4.5
% loss on ignition at 1900°F. after 3 hours at specified temperature	60.6	59.6	59.7	53.1
Total percent volatile matter	60.7	60.4	60.8	57.6

You will note in the first chart which is the wet application, that the loss is all of the water contained plus a slight amount of the remaining volatile. Since on a weight basis, the powder is about ¼ of the make-up, if you will multiply the percent loss figures at 1900°F. by four, you will get an idea of the amount of volatile which would be present for loss during the pouring operation.

217

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW 9, MICHIGAN

Two of the large EF combination gas fired and electrically heated furnaces we built for uniformly annealing, normalizing, galvanizing, and producing other surface and metallurgical conditions on strip—continuously.

70* Strip Line Installations --- 7 More in Process

The Electric Furnace Company has designed, built and installed gas fired and electric furnace equipment for the following continuous strip steel processing lines:

18 for galvanizing and aluminizing steel strip
25 for processing silicon steel strip
12 for bright annealing stainless steel strip
9 for miscellaneous operations on high and low carbon strip
6 for special strip processes—not publicized
7 more are now in process of engineering and building

Considerable engineering experience, ability and "know how" were important factors in designing, building, and installing this equipment—for some of the world's leading strip producers and processors.

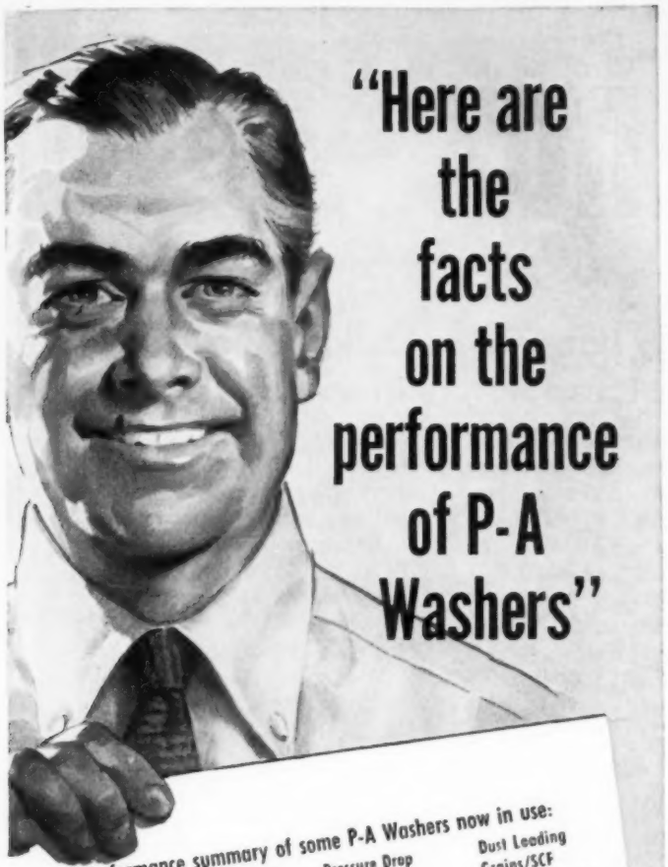
We have the engineers, the research, the experimental and the complete manufacturing and erection facilities to handle your ferrous or non-ferrous strip, wire, tubing or any other heat processing problems.

EF **THE ELECTRIC FURNACE CO.**
GAS FIRED, OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION
Salem - Ohio

Canadian Associates • CANEFCO LIMITED • Toronto 1, Canada

Approximately 90% of above equipment was completed since 1945.

One of the numerous types of continuous furnaces we have built for processing various grades of silicon strip.



"Here are the facts on the performance of P-A Washers"

Performance summary of some P-A Washers now in use:

Installation	Years Operated	Volume SCFM	Pressure Drop Inches Water	Dust Loading Grains/SCF Inlet	Outlet
A	4	78,000	30	3-19.0	.01-.04
B	3½	78,000	30	2-3	.02-.08
C	3	85,000	30-40	2-3	.01-.03
D	3	45,000	30	2	.02-.03
E	½	75,000	50	—	.02
F*	½	26,000	12	5	.10
G*	½	26,000	12	5	.10
H	½	90,000	29	—	.04

*Two units in parallel on one furnace. Lower efficiency due to lower available top pressure.

These actual performance figures reflect the highly efficient operation of the Pease-Anthony washer. This venturi scrubber puts your full top pressure to work cleaning the gas. No secondary cleaner required for most installations. Present users report no maintenance problems. If you have a blast furnace scheduled for construction or rebuilding, plan now for P-A Venturi installation. Capacities up to 150,000 SCFM. Write for bulletin M-103.

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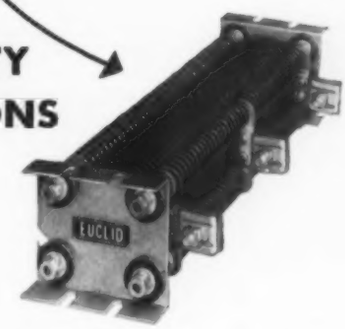
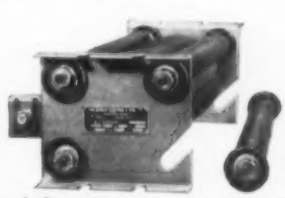


All Steel and Mica Construction provides a truly non-breakable resistor.

Continuous stainless steel edge-wound coil without joints eliminates hot spots, buckling and distortion.

Support rods on outside of coil permit unobstructed cooling air flow and compact design for smaller size and less weight per horsepower.

Exclusive slotted design



Slotted end frames permit removal and replacement of coil without disturbing rod assembly.

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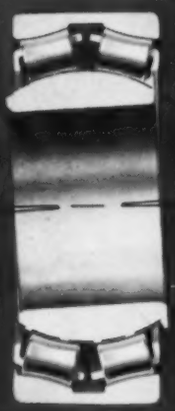

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Husky bearings in husky housings adjust immediately in any direction

When high-impact loads deal out punishment, shaft deflection may spell a quick finish for ordinary bearings. But this rugged Link-Belt bearing is *self*-aligning . . . won't "pinch" or bind when misaligned.

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Series 6800, 6900, 7800, 7900 roller bearings have internationally standardized boundary dimensions.

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Personnel News...

Ernest T. Weir resigned as chairman of the National Steel Corp. in a letter to the stockholders at their meeting on April 24, and recommended to the board of directors that **Thomas E. Millsop,** president, be named the chief executive officer by amending the bylaws which provide that the chairman of the board is the chief executive officer. Mr. Weir will continue as director and stated that he is going to recommend an outstanding man to be named chairman of the board, but did not mention his choice. Mr. Weir has been with the National Steel Corp. ever since its formation, and with the Weirton Steel Co. since its formation in 1905. Mr. Millsop has been with Weirton since 1927. Starting as salesman, he became successively assistant sales manager, assistant to the president and vice president. In 1936 he became president of the company; in 1954 he was named president of the National Steel Corp. and vice chairman of Weirton Steel.

T. M. Hunter was named assistant to vice president—operations of United States Steel Corp. At the same time, **A. T. Duff** succeeded Mr. Hunter as general superintendent of Irvin Works and **G. P. Carson** succeeded Mr. Duff as assistant general superintendent there.

Mr. Hunter joined U. S. Steel in 1936 as assistant to the tin house superintendent of Shenango Works. In 1937, he transferred to Irvin Works as assistant to the superintendent of the tin finishing department, and after several promotions was made superintendent of flat products at the plant in 1941. He was transferred to Gary Sheet and Tin Mill, Gary, Ind., in 1944 and was tin mill division superintendent at the time of his return to Irvin Works as assistant general superintendent in 1950. He was made general superintendent of the plant in 1955. Mr. Duff began his U. S. Steel career as a weigher in the cold reduction department of Irvin Works in 1938, at the time Irvin was first placed in operation. He served successively as foreman and assistant superintendent of the 80-in. hot strip mill, general foreman of the tin finishing department, assistant superintendent of cold reduction and superintendent of Irvin's galvanizing department. In 1950, he became superintendent of the 80-in. hot strip mill, and two years later was transferred to Fairless Works as superintendent of tin finishing. He returned to Irvin Works in 1955 as assistant general superintendent, the position he held at the time of his present appointment. Mr. Carson started with U. S. Steel's Gary Sheet Mill in 1935. Transferred to Irvin Works in 1938, he was promoted several times before being made superintendent of cold reduction in 1954. He was transferred to the Gary Sheet and Tin Mill in 1956, as division superintendent of the Sheet Mill and held that position until his present appointment.

E. Milton Barber will retire as vice chairman of Pittsburgh Steel Co., and as executive vice president of its subsidiary, Johnson Steel & Wire Co., Inc., effective July 1. Mr. Barber will be retained as a consultant to assist in supervising the completion of the company's current 21-million dollar expansion program. **P. E. Sance** was elected to succeed Mr. Barber as executive vice president of Johnson Steel & Wire. Mr. Sance will continue to serve as a vice president of Pittsburgh Steel. Succeeding Mr. Sance as vice president—operations will be **Carl A. Breuer,** formerly general manager of operations. **Joseph R. Carter,** who has been in charge of operations at Johnson Steel & Wire, becomes assistant to the vice president—operations of Pittsburgh Steel.

William G. Walk has been appointed general superintendent of U. S. Steel Corp.'s Johnstown, Pa., Works, succeeding **Thomas P. Riley** who retired April 30. Mr. Walk began his career with U. S. Steel in 1930 as a metallurgical engineer at the Clairton Works. In 1932 Mr. Walk moved to the Homestead Works as a metallurgical observer then foreman of the observer corps. He later became associated with the Wheel and Axle division and was successively chief metallurgist, general foreman of the rolling and forge department and assistant superintendent. In 1943 Mr. Walk was promoted to assistant superintendent of the No. 5 open hearth shop at Homestead and progressed to assistant to the general superintendent of the plant, superintendent of the heat treating and forge division and in 1951 division superintendent, central maintenance. In 1955 he was advanced to assistant general superintendent of the Johnstown Works, the position he held at the time of his present appointment. Mr.

ERNEST T. WEIR

THOMAS E. MILLSOP

T. M. HUNTER

A. T. DUFF

A. A. KAPPENHAGEN

JOSEPH TURNER

M. L. STAMBAUGH

JOHN G. GARLAND

Riley had been general superintendent at Johnstown Works since 1946. He ended his career after more than 46 years of service with U. S. Steel.

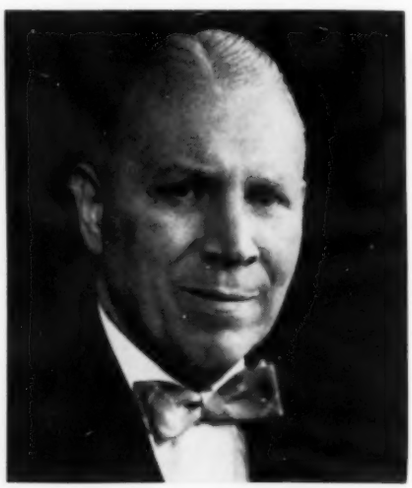
Arthur A. Kappenhagen has been appointed division superintendent of Republic Steel Corp.'s Youngstown, Ohio, steel plant. **Joseph Turner** succeeds Mr. Kappenhagen as superintendent of open hearth furnaces, and **M. L. Stambaugh** replaces Mr. Turner as assistant superintendent of open hearth furnaces. Mr. Kappenhagen joined Republic in 1935 as a turn foreman in the labor department in Cleveland. He subsequently was made dock foreman, assistant labor superintendent, general foreman of the open hearth department and assistant superintendent of open hearth furnaces in Cleveland before moving to Youngstown in 1953 as superintendent of open hearth furnaces. Mr. Turner joined Republic in Youngstown as a third helper in the open hearth department in 1936. He was made second helper in 1937 and first helper in 1938. In 1941 he was promoted to melter foreman in the open hearth department and in 1947 was appointed assistant superintendent of open hearth furnaces. Mr. Stambaugh also joined Republic in 1936 and worked his way up from third helper in the open hearth department. He was appointed junior melter of open hearth furnaces in 1949 and senior melter in 1954.

John G. Garland, formerly assistant division superintendent, maintenance at United States Steel Corp.'s Duquesne Works, has been promoted to division superintendent, maintenance. Mr. Garland succeeds **C. B. Brundage, Jr.,** who was named assistant general superintendent at Duquesne Works.

David L. Richardson, Jr., has been appointed staff industrial engineer for Jones & Laughlin Steel Corp. Mr. Richardson, who formerly was supervisor, planning and operations analysis at J&L's Cleveland Works, will be assigned to planning and operations analysis in the general office at Pittsburgh, Pa.

Bruce Alexander has been appointed manager of technical services at the Washington, D. C., office of Blaw-Knox Co. He succeeds **Marvin Marcus,** who has resigned to establish his own business as a Washington consulting engineer. Mr. Alexander joined Blaw-Knox in 1944 and has been employed in engineering, sales and management capacities in company units serving the chemical and process industries. He also served Aluminum Co. of America for five years as a project engineer.

John F. Black, formerly assistant manager, Freyn Department, Koppers Co., Inc., has joined Selas Corp. of America as manager of sales of the firm's newly-created Steel Mill Division. Mr. Black's steel mill experience began in 1925 when he joined Bethlehem Steel Co. as a pipefitter helper at the Sparrows Point, Md., plant. He advanced steadily to become mill



JOHN F. BLACK

foreman, combustion engineer, assistant fuel engineer and finally general foreman of pipe mills. In 1941 he transferred to Atlas Steels, Ltd., Welland, Ontario, as fuel engineer and furnace designer, and later was made assistant works manager. He was appointed general superintendent of the Buffalo plant, Wickwire Spencer Steel Division, Colorado Fuel and Iron Corp. in 1947, and two years later joined Youngstown Sheet and Tube Co. as assistant general superintendent at its Indiana Harbor, Ind., plant.

Wm. A. Faville has joined the Faville-LeVally Corp., manufacturers' representative selling heat transfer equipment to the utility, steel, oil and chemical proc-

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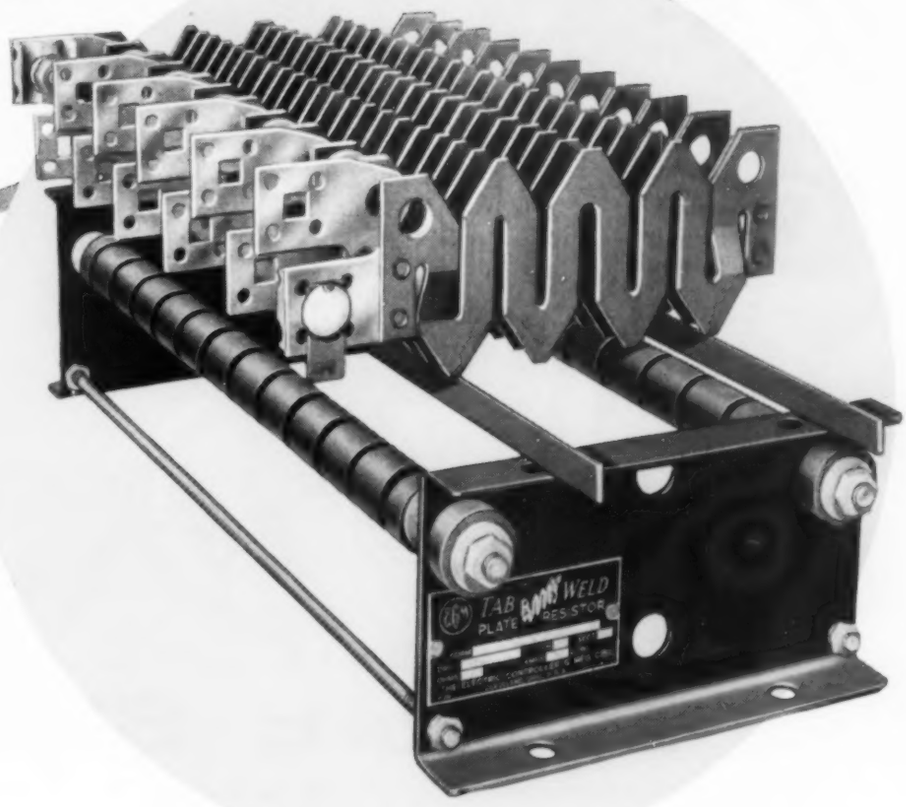

Unlike other resistors, EC&M Tab-Weld Resistors do *not* require periodic tightening of clamping nuts to compensate for loss of pressure caused by alternate heating and cooling. Grids are offset and mating ends are spot welded. Tap-plates are also welded into place at close intervals along the grid assembly...This EC&M construction offers 4 big advantages on heavy duty motor applications: *(1)* stabilized ohmic value *(2)* no burning at grid-eyes or at tap-plates *(3)* easy tap-shifting for best motor performance and *(4)* long life without maintenance!

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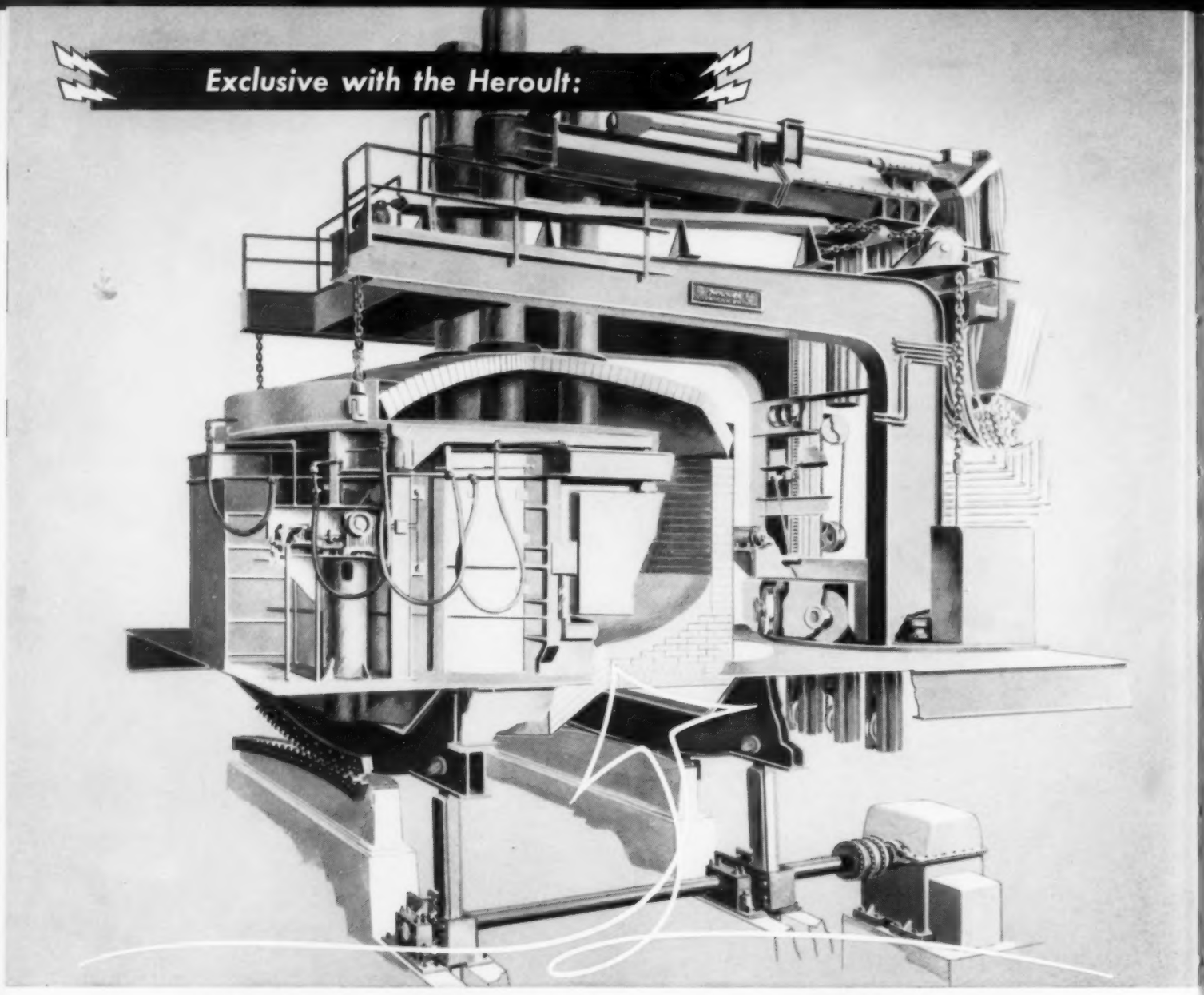

Flat Bottom Shell

THE EXCLUSIVE Flat Bottom Shell construction of Heroult's NEW electric furnace facilitates installation of the hearth lining, resulting in lower refractory costs and shorter down time for relining.

The advanced Flat Bottom design of the NEW Heroult furnace provides maximum protection against burnout.

Flat Bottoms also permit the use of thicker refractories at the sides of the hearth, resulting in more uniform bath temperatures, essential for the production of quality steels.

The simple, rugged supporting structure possible with the Flat Bottom Shell makes the removable shell feature economically feasible.

NEW Heroult furnaces are available in a range of sizes capable of holding capacities from 6,000 to 400,000 pounds. You can select door charge or top charge models, with gantry or swing top moving roofs; there is available special induction stirring equipment and duplexing and non-ferrous furnaces.

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UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

ess industries. He was formerly district manager for the Petroleum Engineer Publishing Co. in Cleveland, Ohio, and Pittsburgh, Pa.

M. Nielsen has been elected president of the Babcock & Wilcox Co. by the board of directors. For the past two years executive vice president of the company, Mr. Nielsen succeeds **Alfred Iddles,** who is retiring after serving as president since 1948. Mr. Nielsen joined

M. NIELSEN

B&W in 1924 as a construction worker in the company's Chicago district. He rose to district inspector, and in 1937 was made district erector in charge of the Cincinnati, Ohio, district. Mr. Nielsen was promoted to superintendent of marine erection in 1939 and in 1947, he moved up to production superintendent of the firm's largest plant, in Barberton, Ohio. Appointed an executive assistant in 1950, Mr. Nielsen moved to B&W's New York offices to take charge of its contract department. In 1952, he was elected assistant vice president of the Boiler Division's manufacturing department, and vice president in 1953, in charge of all Boiler Division manufacturing. Re-elected in 1954, he was made head of the entire division, and at the same time became a member of the board of directors. The next year, he was elected executive vice president.

W. W. Lusk was appointed manager of machinery sales, United Engineering and Foundry Co. Mr. Lusk joined United in 1936. From 1940 to 1945 he was assistant to the chief engineer. In 1945 he became a sales engineer, which position he has held until the present time.

F. E. Stouffer has been appointed vice president and plant manager of Pennsylvania Transformer Division, McGraw-Edison Co. For the past seven years Mr. Stouffer has served as manager of the Canonsburg, Pa., plant of Radio Corp. of America, with which he had been associated since 1935.

Samuel S. Rickley has been named Pittsburgh representative for Morgan Construction Co., succeeding **Henry H. Wood.** Before joining Morgan in 1951, Mr. Rickley was chief engineer of Superior Steel Corp. Mr. Wood will continue to be active for Morgan in the Pittsburgh area, but will devote his time to special projects.

Rudolph Tietig, Jr., has joined Kaiser Engineers as a principal engineer, Steel Plants Division. Mr. Tietig comes to Kaiser from a firm of Chicago engineering consultants with whom he was associated for the past 10 years. There he pioneered in developing the use of oxygen in open hearth steelmaking and served as project engineer for the design of numerous steelworks facilities. Previous to this, he was general superintendent of what is now the Acme-Newport Steel Co., Newport, Ky.

Charles L. Hoebel has been appointed district manager of the New York office of Elliott Co. Mr. Hoebel joined the Elliott New York office as a field engineer in 1952.

William D. Gates has been appointed sales representative at Laclede-Christy Division, H. K. Porter Co., Inc. Mr. Gates will headquarter in Pittsburgh, Pa., and his territory includes western W. Va. and southeast Ohio. He was formerly sales representative for Frazier-Simplex, Inc., and previously was with Bethlehem Steel Co. at Johnstown, Pa.

William S. Stamp has been promoted to district manager of the Buffalo, N. Y., area by Clark Controller Co. He succeeds **Harry Cook,** who will be manager of industrial sales at the Cleveland, Ohio, office. Mr.

W. W. LUSK

F. E. STOUFFER

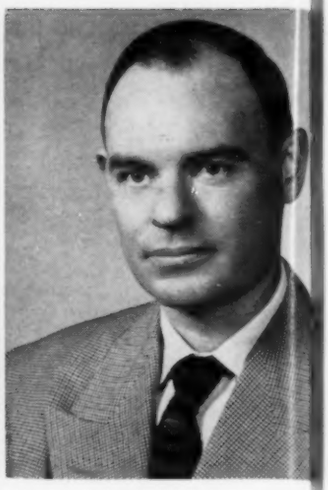
SAMUEL S. RICKLEY

RUDOLPH TIETIG, JR.

DR. EDWIN RUH

CHARLES H. SCHWERIN

C. C. BLACKMAN



R. R. HILL

Stamp was previously Gary, Ind., district manager, and has served in various capacities with Clark since 1946.

Dr. Edwin Ruh has been named assistant director of research for Harbison-Walker Refractories Co. He has been a research engineer in the company's Hays Laboratory and in the home office at Pittsburgh.

Charles H. Schwerin has been appointed manager of West Coast sales for the Mackintosh-Hemphill and Rolling Mill Divisions of E. W. Bliss Co. Mr. Schwerin spent nineteen years with George J. Hagan Co., now a division of Salem-Brosius Co., rising to the position of manager of sales and engineering. From 1954 until his present assignment, he was manager of the Industrial Furnace Division of The Gas Machinery Co.

C. C. Blackman, former assistant chief engineer, has been named director of research for Lee Wilson Engineering Co., Inc. He succeeds **E. A. Corns** who becomes administrative assistant for the company's Proprietorship Operations. Former superintendent of service and construction, **R. R. Hill,** was named assistant chief engineer to succeed Mr. Blackman. He will take on the responsibility of director of field service and construction. **J. R. Moran** was named assistant superintendent of service and construction, and **E. P. Usiak,** combustion engineer. **G. C. Weaver,** former plant superintendent, was named to assistant production manager and plant superintendent. **W. T. Mittler** was named assistant to Mr. Weaver.

E. C. Wilson has been elected vice president of the Illinois Gear & Machine Co. Mr. Wilson has been associated with the company since 1942.

Eugene F. Gardner was appointed a sales representative in the Pittsburgh district for the Midvale-Heppenstall Co. Mr. Gardner was previously associated with Allegheny-Ludlum Steel Corp.

Stanley L. Jameson has joined Engineering Service Bureau, Chicago, Ill., consulting and design engineers for the steel industry, as chief engineer, electrical and mechanical. He was formerly senior engineer—electrical, construction engineering unit, General Electric Co. He joined General Electric in 1934 and has worked on electrical installation and ventilation design for steel mill equipment since 1942.

Bernard Campbell has joined Calstrip Steel Corp. as assistant vice president—operations. Mr. Campbell was previously with Algoma Steel Corp. where he supervised the new cold rolled strip mill.

Harold D. Prior has been appointed technical director of The Chas. Taylor's Sons Co., subsidiary of National Lead Co. Mr. Prior has been manager of National Lead's Washington, D. C., office since July, 1955. He was district sales manager of the division's eastern territory from 1945 to 1955.

HAROLD D. PRIOR

E. M. Richardson has been appointed to the newly created post of general sales manager, Refractories Division, H. K. Porter Co., Inc. He will direct the coordination of Porter's refractory divisions' sales of Laclede-Christy Refractories, McLain Fire Brick, and Mullite Refractories. Until recently, Mr. Richardson was a management consultant in Philadelphia.

Charles C. Thomas has been appointed manager of construction engineering for the Systems Application Engineering Section of the General Electric Co.'s User Industries Sales Department. He replaces **C. P.**

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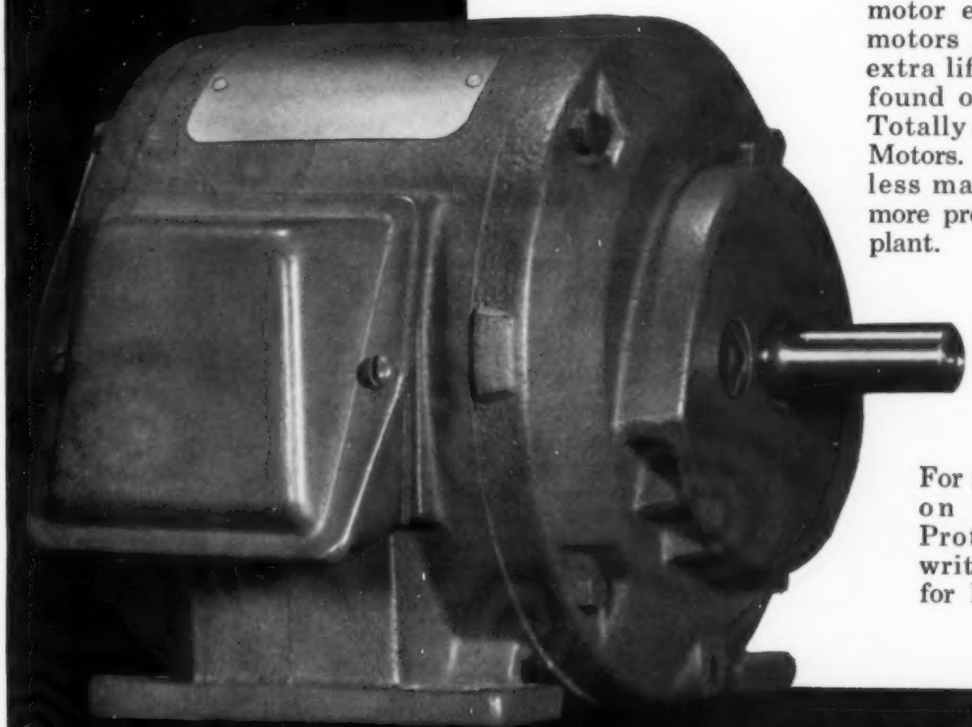

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(B-1543)

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Sullivan who has been appointed senior electrical engineer for the unit. Mr. Thomas joined General Electric's Test Program in 1940. In 1942 he was transferred to the Pacific Northwest district where he worked during the construction and start-up of the aluminum rolling mill at Trentwood, Wash., and the Kaiser Steel Mill at Fontana, Calif. In 1944 he was named as GE representative for the Hanford Atomic Power Project at Richland, Wash., where he supervised the installation of all General Electric equipment. He returned to Schenectady in 1945 as a steel mill application engineer, and in 1953 was appointed senior engineer of special projects in steel mill applications.

Albert M. Dexter, who has been Pratt & Whitney Co.'s manager of gage research since 1954, has been named assistant to the manager of the firm's Gage Division. At the same time, **Arthur H. Wolfson** was appointed manager of gage research.

James K. Wingard has been appointed manager of engineering of the Press Division of the E. W. Bliss Co. Associated with Bliss for 20 years, Mr. Wingard has served in various executive engineering capacities. Since 1953 he has been assistant chief engineer of the Rolling Mill Division.

E. P. Hansen has been promoted to assistant chief engineer of Allis-Chalmers Manufacturing Co.'s steam turbine department, succeeding **H. D. Emmert,** recently named chief engineer. **Cecil H. Morris** has been appointed engineer-in-charge of steam turbine mechanical design to succeed Mr. Hansen.

Loren E. Elliott has recently joined the staff of the Brooks Oil Co. as district representative for the state of Indiana. Prior to joining Brooks he was lubrication engineer with the National Lead Atomic Plant.

James S. Shute, previously assistant to the manager of Selas Corp.'s Combustion Equipment Division, has been named to head the firm's new Export Division. Mr. Shute has been associated with Selas since 1940 and has served in various design and engineering capacities.

W. Basil Leach was elected president of Mexico Refractories Co., and the company's founder, **John B. Arthur,** was elevated from the presidency to the position of chairman of the board and chief executive officer. The board also announced the election of **C. A. Smith,** vice president and chief engineer, to a newly created position of executive vice president, retaining the responsibility of chief engineer. **Carl H. Bachmann,** production manager of the Mexico, Mo., plant, was elected a vice president; he has been a member of the board of directors since early 1955.

Obituaries

Leonid A. Umansky, 66, retired manager of Systems Application Engineering for the General Electric Co., died April 3. A native of Russia, Mr. Umansky came to the U. S. in 1915 as an artillery officer in the Imperial Russian Army, and was assigned at General Electric in Schenectady, N. Y., as an ammunition inspector. At the outbreak of the revolution in 1919, he elected to remain in this country and joined the company as a test engineer. Following experience in numerous phases of engineering, including power and mining, he was sent to Russia in 1931 as a representative of the company's International Division. He was appointed

LEONID A. UMANSKY

manager of engineering for the then Industrial Engineering Department at Schenectady in 1950 after holding several managerial positions. In 1938 Mr. Umansky was granted the Coffin Award, the company's highest tribute for engineering accomplishments. During his career he held 18 patents, and was an active member of the Association of Iron and Steel Engineers.

G. Donald Spackman, vice president in charge of operations of Lukens Steel Co., died April 14. He was 61. Mr. Spackman joined Lukens in 1917 in the mechanical department. He served as a fuel engineer, superintendent of the flanging department, assistant general superintendent, president of the Lukenweld division, general superintendent, and general works manager. He was named vice president of operations in 1943.

C. D. King, assistant to executive vice president—operations, United States Steel Corp., died March 24.

Francis R. Thompson, engineer in charge of the Electrical Engineering Department, Mesta Machine Co. died April 16. Mr. Thompson, started his employment at Mesta in 1937 as an electrical engineer.

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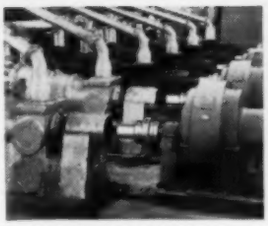
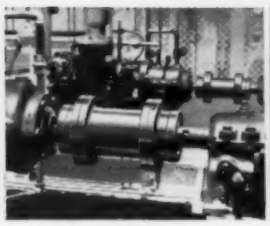
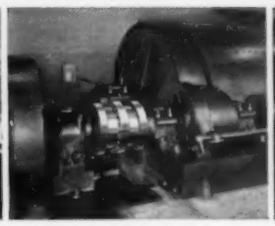


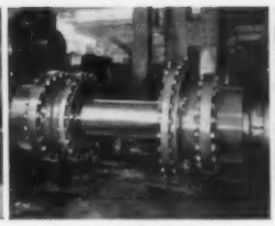
Paper Industry



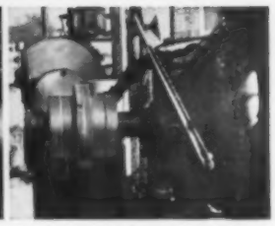
Oil and Gas Industry



Marine Industry

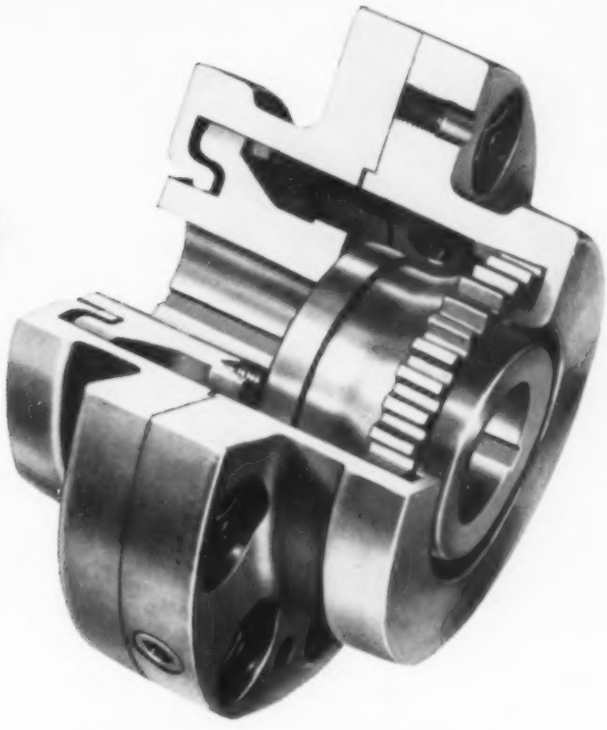


Steel Industry



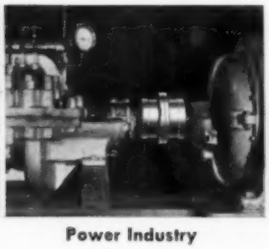
Oil and Gas Industry

Why have Fast's Couplings always been the leader in the rugged steel industry?



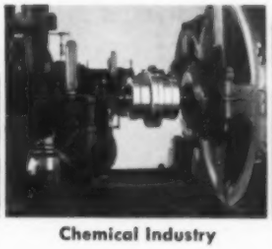
Why are they used so widely to couple machinery in Power Generation, Pulp and Paper, Oil and Gas, Marine Propulsion and Auxiliaries, Steel and industry in general?

Steel Industry



Power Industry

Lumber Industry



Chemical Industry

Paper Industry

Fast's Couplings are standard equipment with more machinery manufacturers than any shaft coupling on the American market. Many Fast's Couplings in use over 30 years still show no signs of wear when disassembled! That's the answer: they're reliable, they're *mechanically* flexible, they don't wear. They have no parts subject to repeated bending, tension or compression. There is no metal-to-metal contact, because of *positive lubrication.* Regardless of your field — no matter whether your connected machine is driven by steam turbine or electric motor, low-speed diesel or high-speed gas turbine . . . Koppers has the perfect, low-cost solution to your shaft coupling problem.

For free catalog write to: KOPPERS COMPANY, INC., *Fast's Coupling Dept., 3005* Scott St., Baltimore 3, Md.

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Aeromaster Fans, Industrial Gas Cleaning Apparatus, Gas Apparatus.

Engineered* Products Sold with *Service

KOPPERS

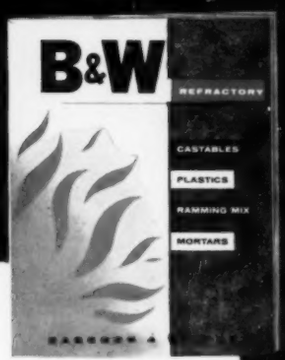
THE ORIGINAL

FAST'S Couplings

What are your refractory castable problems ?

- High Temperatures?
- Abrasion and Erosion?
- Slag Attack?
- Overhead Applications?
- Insulating Properties Required?

B&W makes a wide range of specialized refractory castables. Whatever your problem, you will find helpful data in B&W Bulletin R-35. Send for your copy today.



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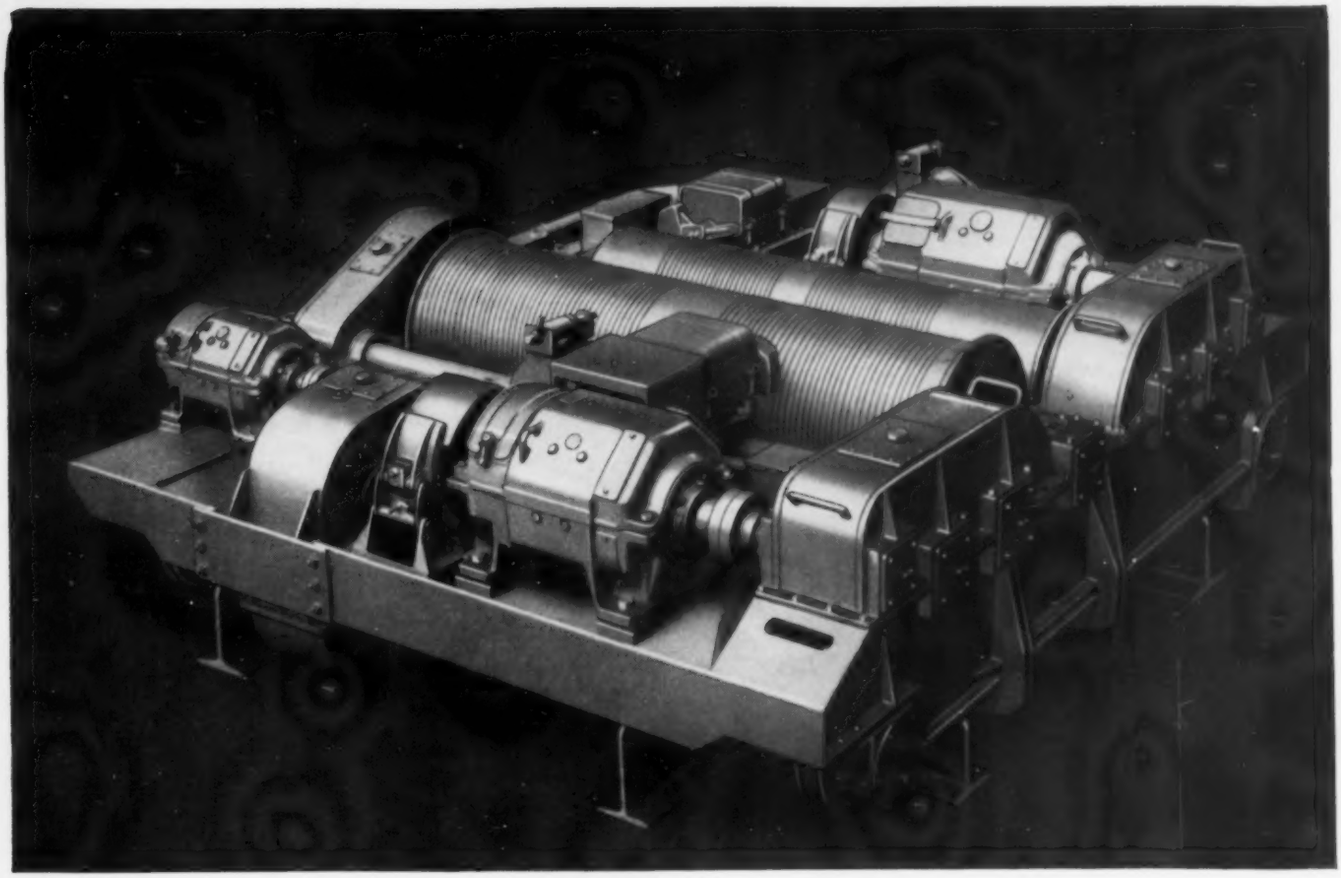
BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

B&W REFRACTORIES PRODUCTS: B&W Alumo Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick • B&W Refractory Castables, Plastics and Mortars • B&W Silicon Carbide



VICTOR R. BROWNING *Trolleys*

FOR HEAVY DUTY MILL TYPE CRANES

"Simple Design is Sound Design"

We offer a complete line of trolleys built to meet the most exacting requirements. These trolleys are constructed of the finest materials available. No cast iron is used. All shafts are of highest quality alloy steel. All bearings are calculated with a proper life factor for service required as defined by the A. I. S. E. We will build a trolley to fit your special requirements as to gauge, head room, approaches and general arrangement. We also make a complete line of cranes for steel mill use. . . Your inquiries will be welcome.

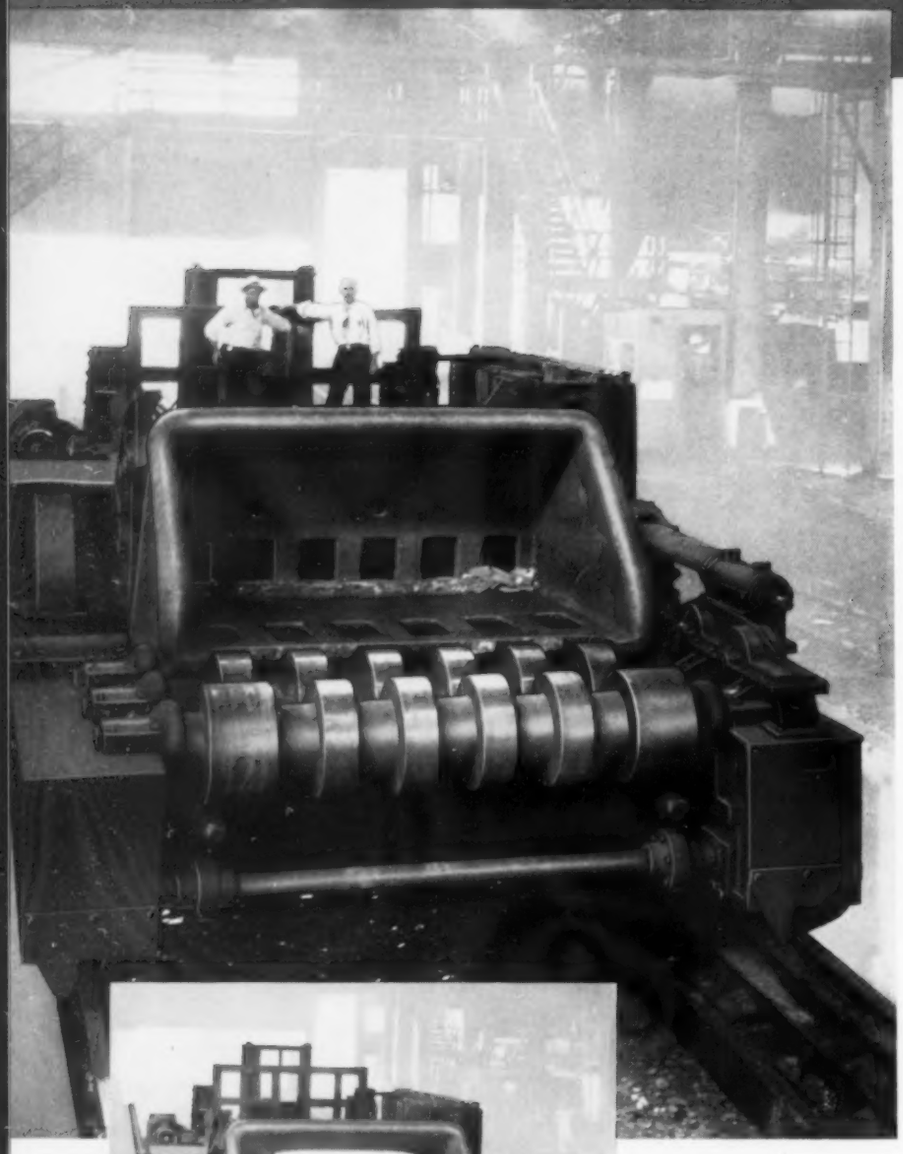
VICTOR R. BROWNING & COMPANY, Inc.

BOX 309, WILLOUGHBY (CLEVELAND), OHIO

Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

INGOT BUGGY...

Serving "The World's Largest Plate Mill"



This buggy is designed to convey 60 to 75-ton ingots from the soaking pits to "The World's Largest Plate Mill." The buggy is equipped with 4 motors . . .

1 for longitudinal travel
1 for tilting the ingot pot
1 for driving the rollers
1 for driving the push-rods which pass through the square holes at the bottom of the ingot pot when the ingot pot is fully tilted. These push-rods push short ingots onto the motor-driven rollers.

Check your heavy material handling needs with Alliance. Their engineers will cooperate with you to develop the most efficient equipment.

Buggy with ingot pot in tilted position.

Same as No. 1 with ingot.

75-ton ingot in vertical position in ingot pot.

"Give us the Runway and we'll lift the World"

THE Alliance MACHINE COMPANY

MAIN OFFICE • ALLIANCE, OHIO

FOUNDED 1901

Manufacturers of:

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES
OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION • COKE PUSHERS • ORE BRIDGES • SHEET CARRIERS

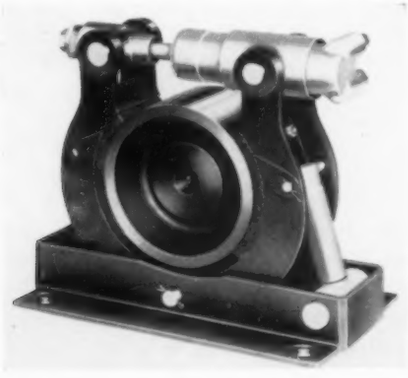
Equipment News...

HYDRAULIC BRAKE

▲ Manufactured by Wagner Electric Corp., is a 6 x 3-in. hydraulic brake designed to provide smooth, powerful service braking and accurate load spotting control on light industrial cranes. It is also suited to other applications, including tension control on mill roll stands and emergency stopping, holding and service braking on many machines and devices. The standard brake is designed for use with hydraulic brake fluid only; if specified, the brake can be furnished with mineral oil compatible parts for special fluid power holding operations.

This new brake, the smallest in the Wagner line of industrial brakes, is also available as a combination service and parking brake which provides automatic emergency braking in the event of power failure.

The hydraulic actuating cylinder, of rugged construction to enable it to stand up under heavy industrial service, is operated through a manual control cylinder equipped

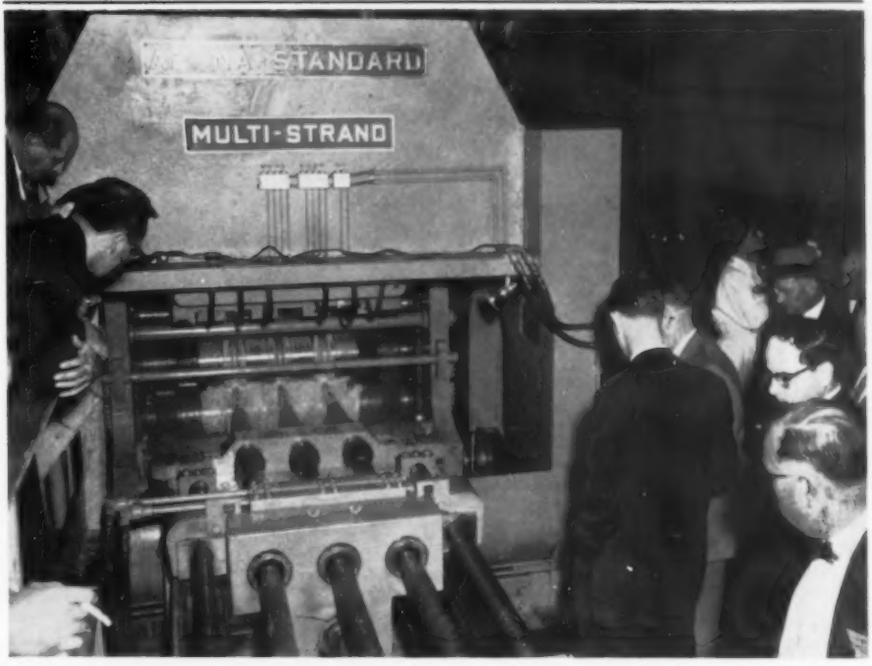


with a foot pedal. The brake arms are forced apart by a compression spring inside the actuating cylinder when the hydraulic pressure is released. One-point brake adjustment to compensate for lining wear is quickly and easily performed.

The brake is equipped with a specially designed anti-drag device hinged between the base member and the right brake shoe arm to prevent the brake shoes from dragging on the brake wheel when the shoes are in released position.

Extra-thick, non-scoring blocks of molded lining are firmly bolted to the brake shoes. Bolted attachment permits convenient replacement of lining when necessary with new predrilled replacement blocks. Lining blocks are reinforced with strong wire backing and the bolt holes are deeply countersunk to allow for full lining wear.

MILL PROCESSES UP TO SIX TUBES AT ONCE



A multi-strand cold tube rolling mill developed by Aetna-Standard Engineering Co., combines the principles of rolling and drawing to give a breakdown unit capable of producing standard tubes 1¼ or 1½ in. outside diameter direct from a pierced or extruded shell 3 in. in diameter. Three, five or six tubes may be processed simultaneously. Positive mechanical feed insures continuous operation, with no shutdown for loading. As an example, tubes enter the mill 3⅛ in. outside diameter x 0.35 in. wall thickness, and leave the mill 1½ in. outside diameter x 0.07 in. wall thickness—an elongation of 10. This machine is designed for maximum speeds of 100 strokes per minute, with 4 in. of finished tube delivered per stroke. The heavy reduction (90 per cent) is equivalent to five cold draw passes. Introduction of the rolling principle eliminates the pointing of tubes and subsequent sawing. The combination of rolling mill and bull block offers reductions in manpower, floor space and handling facilities. Tubes roughed on this machine are given a final reduction, without annealing, on a conventional bull block. Originally developed for copper, the machine has successfully rolled brass and aluminum, and just recently has processed steel tubing satisfactorily.

TRANSMITTER

▲ A speed transmitting device that produces a pneumatic output linearly proportional to rotational speed has been designed by the Foxboro Co. This new device will measure the speed of any rotating machinery and is particularly applicable to turbines, conveyer lines, compressors and mill equipment.

The transmitter operates on the force balance principle with magnetic actuation of a standard pneumatic circuit. Connected to rotating equipment, the transmitter input shaft spins a multipole permanent magnet, rotating a magnetic field through a non-magnetic disk close to the magnet poles. The disk, with a force bar attached, tends to rotate in the same direction as the magnet, positioning the bar in relation to an

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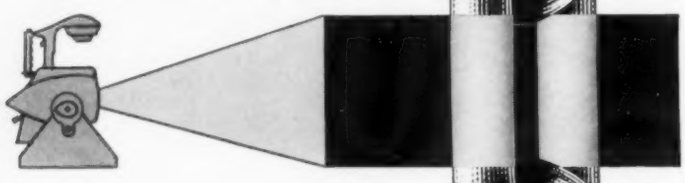
QUALITY CONTROL
on master, joiner and end links
makes TM
factory made
ALLOY SLING CHAINS
the PREFERENCE wherever
PLANT SAFETY... LOW MAINTENANCE
and FEWER REPLACEMENTS are factors!



Taylor has been authorized by the AEC to use Gamma Ray for quality control on master, joiner and end links. This, in addition to our rigid standards, plus Controlled-Atmosphere Heat-Treating of popular chain sizes, and patented TAYCO Safety Hooks is your big assurance of slings that are tougher, safer—last longer and cost less. A test certificate bearing the chain's serial number is furnished with every TM factory made, alloy sling.

Call your DISTRIBUTOR today for all the facts and complete specifications!

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A GREAT NAME IN
Chain SINCE 1873

S. G. TAYLOR CHAIN CO., INC.
A complete line of quality chain!
Main office and plant—Hammond, Ind.
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3505 Smallman St., Pittsburgh, Pa.

air nozzle. The resulting back pressure in the nozzle circuit, amplified by a relay, exerts force, through a free-floating ball piston which bears on the force bar, to balance the torque produced on the disk by the rotating magnet. This 3–15 psig feedback pressure is received by an indicator, recorder or controller calibrated in units of speed.

The transmitter is small, light and easily installed. Gasketed construction and continuous air bleed prevent dust and weather damage. No electrical hazards are present. The effect of ambient temperature on magnetic field strength is compensated by the bi-metallic input shaft which automatically varies the spacing between magnet and disk with temperature changes.

Transmitter range is adjustable from zero to 1600 rpm up to zero to 2400 rpm by a fine range adjustment screw, and extended to zero to 320 rpm through zero to 5300 rpm by optional speed changers. The instrument can be assembled to measure clockwise or counterclockwise rotation, or the 3–15 psig output can be split to accommodate both forward and reverse rotation within the maximum range limit.

POWER SWITCHING UNIT

▲ Introduced by the R&IE Equipment Div., I-T-E Circuit Breaker Co., is a new type of power switching center. This switching center has wide application on industrial distribution systems where interrupter switches and fuse protection are desirable on circuits up to 14.4 kv.

These power switching centers incorporate two or more interrupter switches, usually fused, in adjacent free standing housings. They are connected with one or more three phase buses and ground bus.

Power switching centers can be used for radial distribution systems, loop systems, throat or cable connected; continuous process systems with double bus feeders and for unit substations.

Switches are normally manually operated, but can be provided with electrical operation. A fast acting TOG-L snap mechanism can also be used especially when high speed operation is desirable.

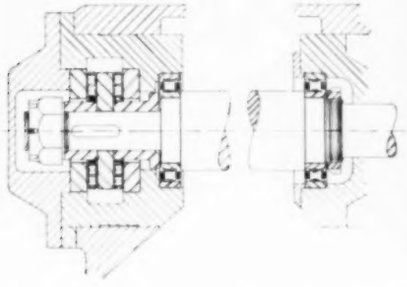
Power switching centers can be supplied in nominal voltage ratings

of 4.8, 7.2, 13.2 and 14.4 kv, and in current ratings of 600 amperes, 40,000 amperes momentary, and 1200 amperes with 60,000 amperes momentary.

THRUST BEARING

▲ Manufactured by Rollway Bearing Co. is a special double-acting thrust bearing designed to withstand extremely heavy thrust loads from either direction. A flat-seat type bearing, with 2-in. bore and $6\frac{3}{16}$-in. O.D., it consists of center plate, two roller assemblies, two stationary plates, and two rotating inner sleeves.

Plates, $\frac{7}{8}$ in. thick, are held to extremely close parallelism to maintain maximum linear contact. Inner



sleeves and center plate are keyed to pinion shaft to insure positive rotation under all conditions. Stationary plates are ground on O.D. for slip fit in the housing, with bores providing proper clearance around inner sleeves.

Machined bronze retainers contain four $\frac{1}{2}$-in.-diameter rollers in each of sixteen slots. Three rollers are $\frac{1}{2}$ in. long; the fourth, $\frac{3}{8}$ in. in length, is staggered to equalize distribution of wear. Thrust capacity of bearing is 17,550 lb at 750 rpm.

Right hand end of inner sleeve is extended and heightened to contact rotating inner race of radial bearing. The Type ML Rollway radial roller bearing, with sixteen $\frac{5}{8}$ x $\frac{5}{8}$-in. crowned rollers, has double-flanged inner race, single-flange separable outer race. Radial capacity, at 750 rpm, is 6,300 lb.

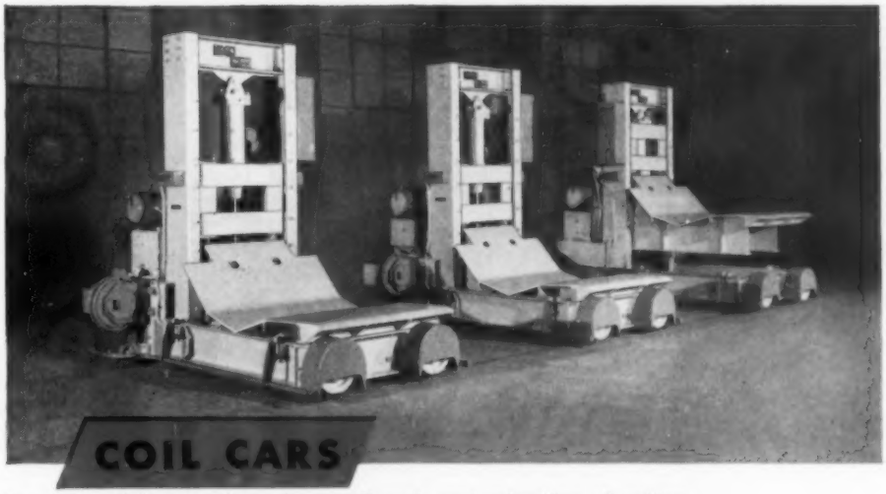
PINHOLE DETECTOR

▲ A new pinhole detector, capable of detecting holes down to one mil in diameter in opaque strip steel measuring 0.01 in. or less, has been announced by the General Electric Specialty Control Department.

The device, a redesign of an earlier General Electric pinhole detector,

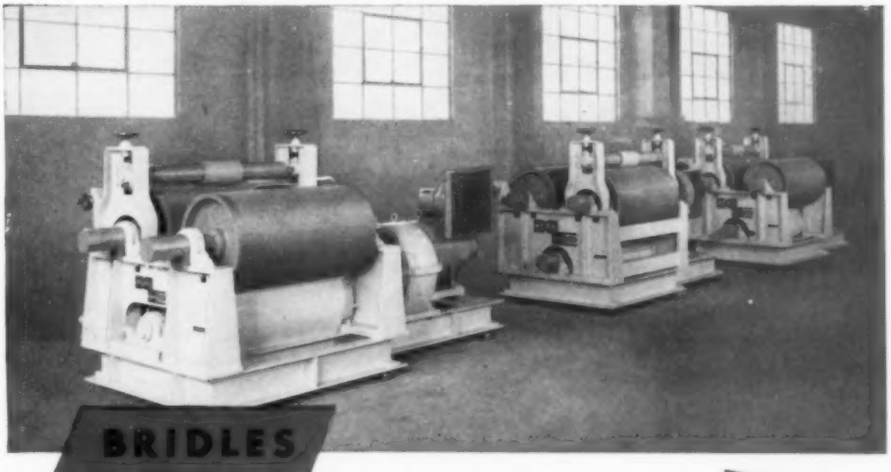
HERR EQUIPMENT

"Complete Processing and Handling Equipment . . . for any Ferrous or Non-Ferrous Material . . . That Starts — or Ends — as a Coil"



COIL CARS

For fast, efficient loading of pay-off reels and unloading of coiling reels. Sizes to handle coils of any diameter, width or weight. Hydraulic lift, electric traverse. No pits. Can be fitted with coil ejector, up-ender and other accessories if desired. Furnished complete ready for use.



BRIDLES

Types and sizes to meet any requirement. Plain steel, rubber covered or "Lorig" type self-aligning rolls. Air operated or regenerative brakes. Also four roll type that permits pay-off and coiling reels to be placed at the same end of the line and controlled with a single operator.

Write for fully descriptive Bulletin No. 561 today!

THE HERR EQUIPMENT CORPORATION

1270 VINE STREET • WARREN, OHIO

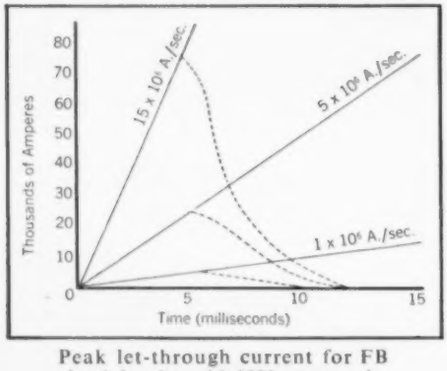
CLEVELAND, INDIANAPOLIS AND BERKELEY, CALIFORNIA

D-C CIRCUIT BREAKERS

Type FB-20 single pole circuit breaker; 2000 amperes continuous, 1000 volts d-c.

NEW "FB" CURRENT LIMITING CIRCUIT BREAKER

Now...complete current limiting protection against fault currents of 1000 to 150,000 amperes



Peak let-through current for FB circuit breaker with 1000 ampere trip.

Small in size, these FB d-c circuit breakers with fast current limiting action provide a tremendous protective capacity. In the event of a fault, powerful springs open the contacts before the current has a chance to rise to its maximum potential.

Even in circuits where the rate of rise might approach 15,000,000 amperes per second, let-through current will not exceed 80,000 amperes. In most applications, it will never exceed 30,000 amperes—and total interrupting time is only 12 milliseconds. This quick action reduces the magnitude and duration of fault currents—thus eliminating mechanical failures and heat damage.

FB circuit breakers are available in either single or double pole models and with continuous current ratings of 1200, 2000, 3000 and 5000 amperes and up to 1000 volts d-c. They are available with either stationary or drawout mounting. Write for Bulletin 3004-A. I-T-E Circuit Breaker Company, Switchgear Division, 19th & Hamilton Sts., Philadelphia 30, Pa.

I-T-E CIRCUIT BREAKER COMPANY • Switchgear Division

IN CANADA: EASTERN POWER DEVICES LTD.

Operator supervises as pinhole detector "passes" on strip steel, speeding along rolling mill at rates up to 2000 fpm.

functions at maximum sensitivity at strip speeds up to 2000 fpm. Up to 20 times the light of earlier units is provided by a new 2500-watt mercury vapor lamp which operates on direct current to eliminate the possibility of "dead bands" in the strip. Engineers say the increased lamp wattage makes possible greater sensitivity in detection of angular as well as vertical holes.

The pinhole detector can now be supplied with versatile, factory-built shutters. The pneumatically-operated shutters "float" on a cushion of compressed air surrounding the strip edge while tool-steel rollers guide the steel through the unit. Shutter openings range from 18 to 48 in. in width.

The unit employs six photomultiplier tubes which outperform similar devices using as many as 30 phototubes. Tubes can be checked in place frequently to assure full detection across the entire strip width. The interior of the detection chamber—a sealed, dust-tight integrating box—has been coated with a flat, highly reflective white finish. Any light which comes through a hole in the strip and through the glass in the top of the chamber will be diffused throughout the entire chamber, according to General Electric design engineers.

Control panel for the unit is a ventilated NEMA Type 1 enclosure, mounted near the scanner and connected to it by wire cables. The panel contains the necessary rectified power supply of 230 volts (plus or minus 10 per cent) 50- or 60-cycle, single phase, 4.4 kva for the lamp, amplifier, and control circuits which act to close the relay contacts upon receiving a signal from the scanner. A burnout relay is provided to sound an alarm in case of lamp failure.

COLOR COAT

▲Available from Insul-Mastic Corp. of America is a new color coat that will stick to and cover black bituminous coatings, old or new, as well as concrete, brick, cinder block, porous roofing tile, asbestos shingles, stucco—and properly primed wood and metal. Dry time is approximately 30 min.

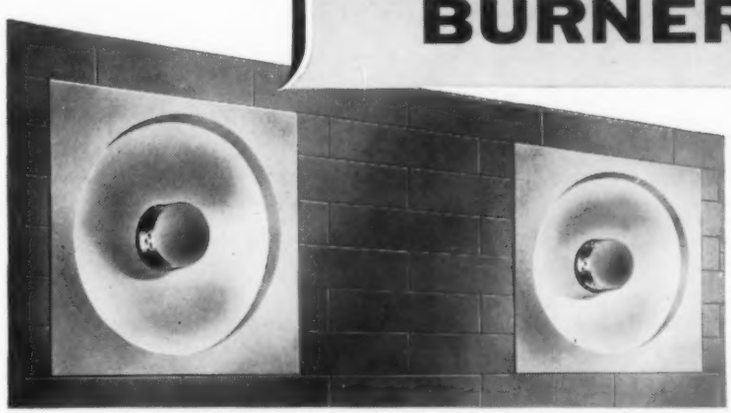
A modified acrylic resin dispersion combined with selected chemically inert pigments, this color coat leaves a tough pigmented plastic film that flexes with expansion and construction of base material. It is especially suitable for color keying service lines.

Known as color coat No. 261, it takes weather in stride, and also shows resistance to sunlight, gases, corrosive fumes, cleaning compounds and many solvents.

It is available in rose, light green, light blue, light yellow, light buff, light gray, dark gray and white—and in an unlimited variety of do-it-yourself colors. It is also safe to

for intense concentration of heat...

The BLOOM HTR BURNER



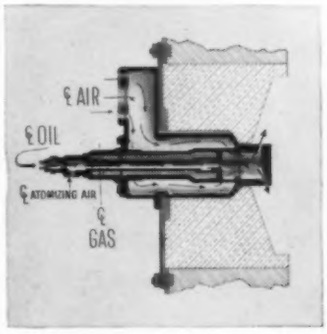
The Bloom HTR Burner provides identical operation on either gas or oil.

This burner enables the engineer to design a heat pattern with excellent results, because it has the unique characteristic of providing localized high heat release with low forward velocity. The burner can be located to fire directly at the material without flame impingement. Roof firing is easily accomplished and provides uniform hearth temperature.

This burner has been very successful in its application to tube upset furnaces; continuous strip annealing, coating, and pre-heating lines; high speed billet heating furnaces; and batch-type forge furnaces.

The Bloom High Thermal Release Burner with its sturdy construction is ideal for applications requiring speed and precision heating.

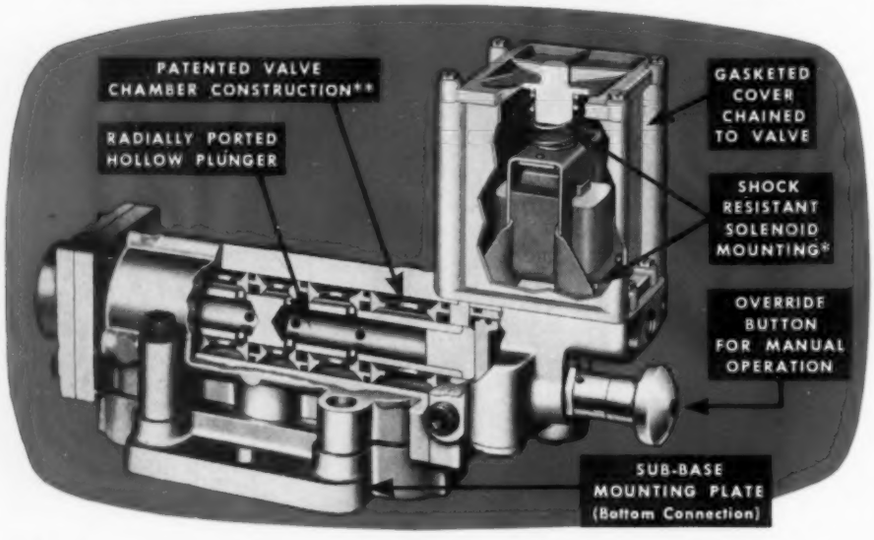
PATENT PENDING



BLOOM ENGINEERING CO., INC.
837 W. North Avenue Pittsburgh 33, Pa.

Quick-As-Wink®

JIC ½" TYPE BJ SOLENOID VALVES


PATENTED VALVE CHAMBER CONSTRUCTION**
RADIALLY PORTED HOLLOW PLUNGER
GASKETED COVER CHAINED TO VALVE
SHOCK RESISTANT SOLENOID MOUNTING*
OVERRIDE BUTTON FOR MANUAL OPERATION
SUB-BASE MOUNTING PLATE (Bottom Connection)

offer users many outstanding advantages

Painstakingly designed, ruggedly built and tested for more than 4 years, these new JIC Quick-As-Wink valves combine: —

1) **HIGH FLOW CAPACITY.** The valves have full ½" pipe capacity.

2) **SHOCK RESISTANT SOLENOID MOUNTING*.** Positioning the solenoid with a spring on resilient rubber rings reduces destructive hammering and pounding, greatly increasing solenoid life.

3) **DIE CAST ALUMINUM COVERS** are fully gasketed, mounted with captive screws, and fastened to the valve with a chain.

4) **SUB-BASE MOUNTING PLATE.** Available in two designs so that pipe connections can be made through the bottom or through the side.

5) **PATENTED VALVE CHAMBERS** are formed by aluminum spacers in accurate metal to metal end abutment** that hold the "O" rings and "U" packers in exact position, and supported on both inside and outside diameters, without mechanical pressure. This proven construction permits repacking easily, quickly and accurately in the field.

6) **OVERRIDE BUTTON** permits manual operation in case of power failure.

MANY OTHER OUTSTANDING FEATURES

Also available in 2 position and 3 position Double Solenoid;—2 position and 3 position Lever Operated;— and Single and Double Pilot Operated Designs.

Get full details about this new valve.
Write for Bulletin No. 571—Today!

*Patent Applied For **U. S. Patent 2,645,450

Quick-As-Wink®
AIR AND HYDRAULIC
Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1925 East Pershing St., Salem, Ohio

store and apply. Application is economical by conventional spray equipment, brush or roller.

REFRACTORY ARCH

▲ A suspended insulating-refractory arch that can be applied without considering the temperature limits of a metal hanger has been developed by the M. H. Detrick Co. The relatively small component parts result in an arch that is easy to install and adjusts to furnace dimensions.

The arch, known as Type ALR, has a low heat storage that makes it applicable to any unit that requires rapid heating and cooling, such as, heat treating furnaces and others which are operated on a periodic cycle.

Because of the many other constructions available, it is possible to use different constructions in the same unit, according to the heat and service requirements. In each case the unit is completely engineered and detailed before installation.

STRAIGHTENERS

▲ Announced by Blaw-Knox Co., is a line of roller-leveler shape straighteners featuring rolls that can be moved to give a variable bending span for straightening squares, flats, angles and other shapes.

The Blaw-Knox Medart machine has an elevating device built into one plane for lining up various pass grooves in the rolls with the pass line of the other plane, thereby reducing the number of roll shapes required.

Roll stands are interchangeable between the first and second sections.

Built in five sizes, the straighteners will handle a range of products from ¼-in. up to 4-in. squares, or the equivalent in cross section. They can process all ferrous products from low carbon through high alloy steels, as well as nonferrous metals.

RELAY UNIT

▲ Announced by Cutler-Hammer, Inc., is the development of a new a-c sensitive relay with transistor amplifier.

The new electronic component, designed to resist vibration, corrosion and shock, hosts an array of

(*Please turn to page 225*)

"Got A Load On Your Mind? I Haven't"

Nothing gives employees a more luxurious, satisfied feeling than that of financial security. And nothing is easier for them to achieve when you provide the convenience of automatic Payroll Savings Plan.

EVERYBODY BENEFITS

Security breeds confidence—and confidence stimulates job interest and results in steadier people who are far more efficient in their work. Receiving those crisp Bonds at regular intervals along with their paycheck is an added inducement for employees to stay on the job.

Moreover, when you install the Payroll Savings Plan in your company, you promote not only the security of your personnel but the security of your company and your country. Over forty million Americans have over 40 billion dollars invested in United States Savings Bonds—a backlog of purchasing power for the future.

EASY TO INSTALL

If your company does not now have a Payroll Savings Plan, or if employee participation is less than 50%, a letter to: Savings Bonds Division, U. S. Treasury Department, Washington, D. C. will bring prompt assistance from your State Director. He will provide application cards, promotional material, and as much personal help as you need.

The United States Government does not pay for this advertising. The Treasury Department thanks, for their patriotic donation, the Advertising Council and

IRON AND STEEL ENGINEER

The pit nobody liked...

except our customers

This is of course our one-way fired soaking pit . . . fired from the top.

The location of the burner is only one of the features responsible for its enthusiastic acceptance. Most important however are the 30 years of experience and refinements which we have built into the pit since we first introduced it.

That is why, today, it is the pit everybody respects . . . especially our customers.

STEEL MILL, HEAT TREAT, GLASS DIVISIONS

SURFACE COMBUSTION CORPORATION

2404 DORR ST., TOLEDO 1, OHIO

wherever heat is used in industry

Associated Companies: British Furnaces, Ltd., Chesterfield • Stein & Atkinson, Ltd., London • Stein & Roubaix, Paris • S. A. Belge, Stein & Roubaix, Bressoux, Liege • S. A. Forni Stein, Genoa • Chugai Ro Kogyo Kaisha, Ltd., Osaka • Benno Schilde Maschinenbau, A. G., Bad Hersfeld

Surface®

GET SQUARE D SAFETY SWITCHES AND BENEFIT FROM THE NEW NEMA STANDARDS

NEMA standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser, as well as to assist the purchaser in selecting and obtaining the proper product for his particular need.

Square D's quick change to the new standards gives you the performance and safety which NEMA standards assure.

Square D Safety Switches cost no more —why settle for less?

DESCRIPTION	HEAVY DUTY New	NORMAL DUTY formerly Types H, S, or A	LIGHT DUTY formerly Types D or G
Rating-Ampere Voltage	30—600 250 or 600V AC, DC	30—1200 250 or 600V AC, DC	30—200 250V AC
Enclosure	NEMA 12 • Industrial Use (Gasketed) NEMA 4 & 5 • Water-tight & Dust-tight NEMA 7 • Explosion-resisting Class I—Group D NEMA 9 • Explosion-resisting	NEMA 1 • General Purpose NEMA 3R • Raintight	NEMA 1 • General Purpose NEMA 3R • Raintight
Horsepower Rating	NEC Fuse Ratings Dual-Element Fuse Ratings	NEC Fuse Rating Dual-Element Fuse Ratings	NEC Fuse Rating
Operating Mechanism	Quick-Make, Quick-Break Independent of Handle	Quick-Make, Quick-Break Independent of Handle	Positive Make, Positive Break Spring Assisted
Cover	Interlocked & Padlock Attachment	Interlocked & Padlock Attachment	Padlock Attachment
Plating—Current Parts	Extra-Heavy Silver	Silver	
Endurance	Maximum Endurance Far Exceeds UL Standards	Exceeds UL Standards	Meets UL Standards

NOW...EC&M PRODUCTS ARE A PART OF THE SQUARE D LINE

SQUARE D COMPANY

(*Continued from page 220*)

standard features which includes a two pole, double throw plug-in relay protected by a clear polystyrene dust-proof cover; a long life plug-in transistor amplifier and power pack module; 12 volt d-c sensing circuit and a low sensing circuit current (less than 0.002 amperes). No warm up time is required and a convenient terminal board is provided for making external connections. It is priced substantially lower than comparable products in the field.

Low capacity contact making devices such as drop wires, feeler switches and gages, contact making instruments, sensitive thermostats and slow-make, slow-break contacts will operate without electrical damage when used with this relay. Its high speed operation makes it desirable for use in stop motion or sorting circuits. The low voltage non-inductive circuit results in no visible arc and thus eliminates fire hazards on applications where the sensing contacts must be near flammable material. Long distance remote control, liquid level control and photo cell applications are also possible due to the relay's sensitivity.

Rated up to 10 amperes, 110 volts, 60 cycles, the relay is available in an open type panel or NEMA type 1 bonderized general purpose enclosure.

ROLLING MILL

Built by the Rolling Mill Div., of the E. W. Bliss Co., is a 4-high type mill with 12 and 36 by 62-in. rolls. As large as many of its type used in the steel industry, this new mill has more than doubled production capacity at Sheet Aluminum Corp.'s plant.

The mill can squeeze 0.125-in. aluminum strip 56 in. wide down to 0.070 in. in a single pass—a reduction of 45 per cent. It will also roll fine gage—all the way down to 0.004 in. And it will roll coils up to 6000 lb.

Maximum mill speed is 1500 fpm. The mill is one-way, with completely mechanized coil-handling and a powered-roller conveyor system to return coils to the entry side for further passes. Backup rolls were produced by Mackintosh-Hemphill Div., E. W. Bliss Co.

The Bliss Co. also designed a new

GOLDEN-ANDERSON VALVES *IN ACTION!*

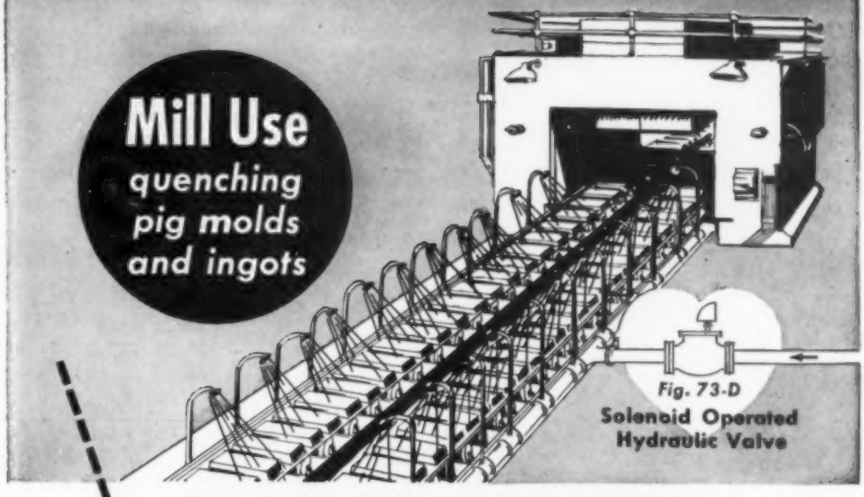


Fig. 73-D
Solenoid Operated
Hydraulic Valve

For automatic quenching of pig molds (illustrated above) or ingots, install the G-A Cushioned Solenoid-Operated Valve. This valve opens quickly, closes at adjustable speed without hammer or shock, is available either normally closed or normally open, and is actuated automatically by push button, trip switch on conveyor, or other type of limit switch.

Available in either Angle or Globe Body Pattern

Write for descriptive technical bulletin W-7A.

Golden Anderson Valve Specialty Company
1220 RIDGE AVE., PITTSBURGH 33, PA.

FREE MARKAL PAINTSTIK!

We will send you without cost or obligation a MARKAL PAINTSTIK. They are available in various types suitable for marking on any kind of material. Hot surfaces up to 2100°F, also welding and heat treating. Cold surfaces down to −50°F, wet, dry, icy, oily, rough, smooth, acid or alkali. ***MARKS Are Permanent, Fadeproof, Weatherproof.*** Specify surface condition, material, temperature at time of marking.

USE THIS COUPON OR WRITE ON YOUR LETTERHEAD!

Here's what I want to mark: _____

_____

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_____

_____ Marking Temperature _____ Max. Temp. _____ °F.

Name _____

Company _____

Address _____

City _____ Zone _____ State _____

My Distributor's Name _____

MARKAL COMPANY 3087 West Carroll Avenue • Chicago 12, Illinois

slitting and shearing line, which takes up to five cuts in 0.125 in. material 56 in. wide at a speed of 200–600 fpm. This is also installed at Sheet Aluminum Corp.

By opening trap doors in the floor between the slitter and its tension reel, a looping pit can be formed to permit simultaneous operation of the slitter and shear. The mandrel of the slitter tension reel is by-passed and the slit strip feeds directly up from the looping pit to the shear and following sheet stacker. The shear will cut any length from two to 17 ft.

AUTOMATIC GAGE

▲ Pratt & Whitney Co., Inc., has announced a new automatic gaging machine that checks the wall and bottom thickness of tubing and automatically separates them into "good," "rectifiable" and "rejected" categories at the rate of 1000 units per hr.

Known as the automatic tube thickness gaging machine, the new device has proved itself by industry-test to be capable of rapid automatic gaging of all types of applications where wall thickness, end thickness and diameter of tubing are to be gaged.

First devised for use with aluminum tubing, the new gaging machine has undergone rigid testing on a production line basis for the past 12 months.

Aluminum tubes are fed into a chute from which they are transferred to a nest of rubber rolls rotating at approximately 600 rpm. As the tubes rotate, gaging contacts enter the open ends exploring the wall thickness on the helix that is generated. At the end of the stroke, bottom thickness is measured. After the gaging slides are retracted at faster-than-gaging speed, the contacts operate two gage heads which sort the tubes into classification conveyors which discharge them into bins of usable, rectifiable and rejected units.

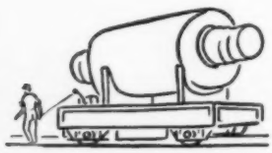
CIRCUIT BREAKERS

▲ Available from Westinghouse Electric Corp., are new circuit breakers that contain a modified AB breaker and a current limiting fuse with three tripping elements; time-delay thermal, instantaneous magnetic, and current-limiting fusible.

The new breaker eliminates any possibility of single-phasing on faults, and can be quickly reset after breaking on overload or usual fault current.

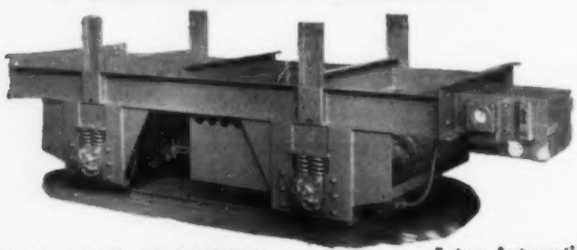
Tripping cause, whether overload, usual fault or extreme fault, is indicated upon resetting of the breaker. Fuse testing is eliminated by the

HANDLES THE BIG LOADS WITH BIG SAVINGS



100-ton Battery Operated

ATLAS *Safety Type* TRANSFERS



5-ton Automatic Controlled

ATLAS SAFETY-TYPE TRANSFER CARS can be provided in almost any capacity for storage battery, diesel or gas-electric, or cable reel service.

They are safe because there is only one control lever, and the car moves only when the operator holds the lever.

Request "Walk-Along" Bulletin 1283.

ATLAS CAR & MFG. CO.
1100 IVANHOE ROAD
CLEVELAND 10, OHIO

ENGINEERS AND MANUFACTURERS SINCE 1896

Tubemakers –

NOW STRIP STEEL BY THE MILE

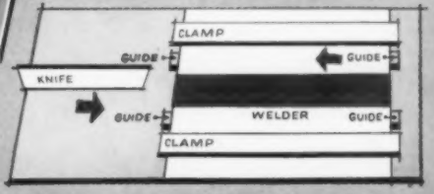
for continuous mill production!

The "MPM SHEAR WELDER" is "a natural" for increasing output and reducing coil end scrap loss.

Perfect welds are a result of positive guiding and clamping, right at the weld area. *(See diagram below.)* Both shearing and welding are done at the same station.

The "MPM" is the fastest, most accurate and compact machine of its kind, that's why tubing manufacturers prefer them over any other type. They are available in a complete range of sizes for any tube mill application. Other types are available for joining strip or sheets of any metal.

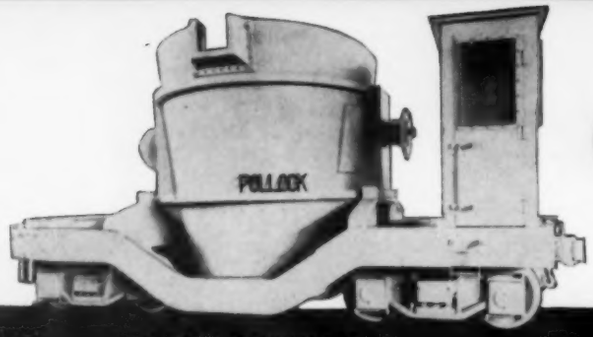
Metal Processing Machine Co.
Subsidiary of The McKay Machine Co.
YOUNGSTOWN, OHIO



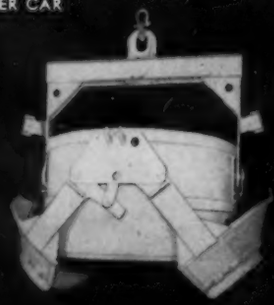
10092

POLLOCK

Open hearth handling equipment

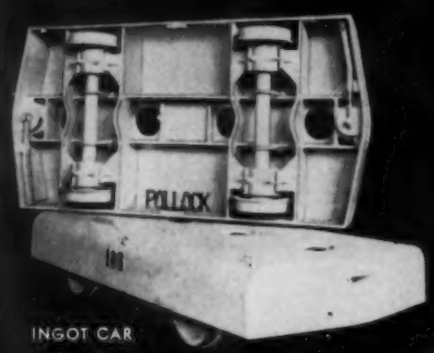


HOT METAL TRANSFER CAR

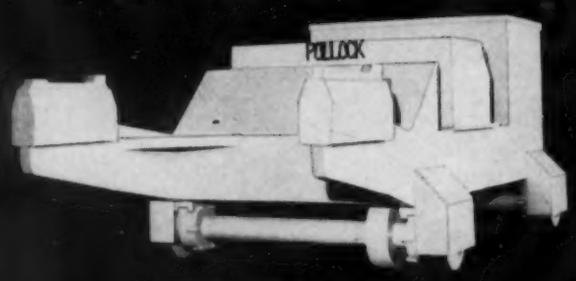


ELECTRIC FURNACE CHARGING BUCKET

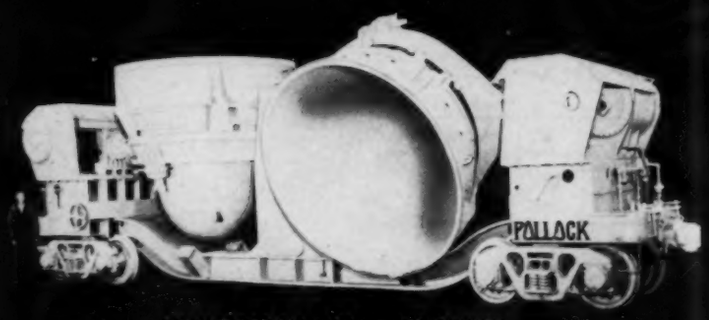
OPEN HEARTH LADLE



INGOT CAR



FRONT-FLUSH SLAG CAR



DOUBLE POT SLAG CAR — AIR DUMPED

an Important factor in increased production

Efficient handling of molten and heavy materials within open hearth plants requires equipment with three characteristics—safety, strength and durability. Pollock equipment meets these necessities. The William B. Pollock Company, in 94 years of operation, has also built more blast furnace handling equipment than any other firm.

When you plan a new open hearth, remodel an existing open hearth or re-equip an open hearth, take advantage of the experience available to you at Pollock. General specifications are available on request. Special-performance details will be engineered to your specifications. Pollock engineers will work closely with your engineers to give you the equipment that meets your needs best.

POLLOCK
SINCE 1863

THE WILLIAM B. POLLOCK COMPANY
YOUNGSTOWN, OHIO

STEEL PLATE CONSTRUCTION • ENGINEERS • FABRICATORS • ERECTORS

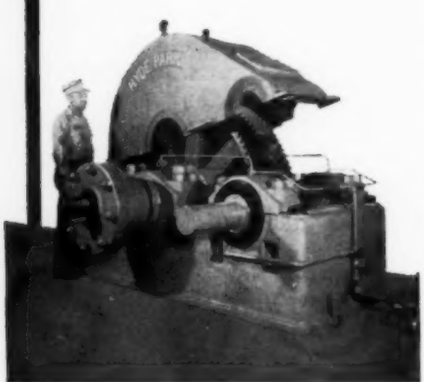
BLAST FURNACES • HOT METAL CARS AND LADLES • CINDER AND SLAG CARS • INGOT MOULD CARS • CHARGING BOX CARS • WELDED OPEN HEARTH LADLES

Hyde Park

RED CIRCLE Rolls ALLOY-CHILLED

Gray Iron Castings

Hyde Park Castings up to 80,000 pounds are sound, accurate and physically dependable.
Precision machining is done by skilled craftsmen in our modern machine shop.
Send your blue prints for quotation.



Mill Drive

Machine Castings
Lathe Beds
Housings
Pinion Housings
Mill Housings
Shoe Plates
Layout Plates
Surface Plates

For finer finish, long life and greater tonnage, specify Red Circle Rolls.

Hyde Park
FOUNDRY & MACHINE CO.
Hyde Park, Westmoreland County, Pa.
ROLLS
ROLLING MILL MACHINERY
GREY IRON CASTINGS

plungers in the special fuses that tell which phase or phases are in trouble.

The breakers are now available in three frames in NEMA standard ratings of 100, 225, and 400 amperes, two or three poles. Ratings of 600 and 800 amperes are to follow. Interrupting capacity at 250 volts direct current and 600 volts alternating current is 100,000-rms amperes.

CONVEYOR BELTS

▲ Two giant conveyor belts made from a high-strength combination of cellulosic fibers and nylon covered with specially compounded rubber by United States Rubber Co., are located at the Holman Cliffs Mine, Taconite, Minn.

Both belts have been in operation since 1948 lifting more than 6,000 tons of iron ore daily. These belts have just completed five years of use without shutdown except for periodic maintenance.

The conveyors lift iron ore from a screen-crushing plant at the mine face to a concentrating plant at the mine rim. The processed ore is then shipped from this plant by rail.

The first conveyor, 884 ft long, lifts the ore a total vertical distance of 170 ft. The ore is then shunted onto the second conveyor, 897 ft long, which lifts the ore an additional 201 ft to the concentrating plant.

The conveyors operate continuously when the mine is being worked. Running at a speed of 650 fpm, they carry a maximum of 1100 tons of ore every hr.

RECORDER

▲ A method to measure generator field temperature has been developed by General Electric Co. The new measurement method combines a double-bridge circuit with an indicating recorder to relate conductor resistance changes to temperature of generator field windings.

Designated as the Kelvin double-bridge indicating recorder, this measurement instrument can be applied to all electric generators used in modern power generation plants.

Field temperature measurements in the new instrument system are based on the principle that resistance of copper or aluminum conductors changes with temperature. When resistance changes with temperature, the Kelvin double-bridge

GENERAL REFRACTORIES

A COMPLETE REFRACTORIES SERVICE . . .

for the Steel Industry

OLIVE HILL BF and OLIVE HILL HI-FIRED brick rank high in any list of prominent and widely used brands of blast furnace refractories. Manufactured from dense-burning Kentucky flint fire clays by Grefco's unique manufacturing processes, OLIVE HILL brick set a standard for blast furnace refractory quality and workmanship.

Grefco processing of OLIVE HILL brick entails:

1. Careful selection, testing, stockpiling and blending of fire clays to insure uniform raw material quality.
2. Grinding and screening to prescribed formula to promote high density of product.
3. Efficient deairing during brick forming, also to promote density and proper physical structure.
4. Careful firing to exacting temperature schedules yields uniform high quality brick.
5. Close inspection of final product with gauging and sorting of brick to close size tolerance.
6. Quality control by statistical analysis procedures for the manufacturing processes.

In service, OLIVE HILL blast furnace brick, both BF and HI-FIRED, have produced many splendid performance records in the past. OLIVE HILL linings in presently operating furnaces, are giving outstanding performance and are more than meeting the increasing requirements of the expanding American Iron and Steel Industry.

GENERAL REFRACTORIES CO.
Philadelphia 2, Pa.

LUBRIPLATE
Nos. 130-AA, 630-AA and 930-AA
are grease type lubricants especially formulated for use in bearings and on other machine parts subject to heavy loads. Have extremely high film strength, marked adhesiveness and water repellence.

LUBRIPLATE
Nos. 4 and 8
are most satisfactory fluid type lubricants over a wide range of temperatures. Due to their high film strength, they are ideal for use where heavy loads are encountered.

REGARDLESS OF THE SIZE AND TYPE OF YOUR MACHINERY, LUBRIPLATE LUBRICANTS WILL IMPROVE ITS OPERATION AND REDUCE MAINTENANCE

For nearest LUBRIPLATE distributor see Classified Telephone Directory. Write for free "LUBRIPLATE DATA BOOK"... a valuable treatise on lubrication. LUBRIPLATE DIVISION, Fiske Brothers Refining Company, Newark 5, N. J. or Toledo 5, Ohio.

circuit is unbalanced, giving rise to an error signal at the recorder. The recorder balances out this signal error through a ratio system and indicates temperature of the generator field windings.

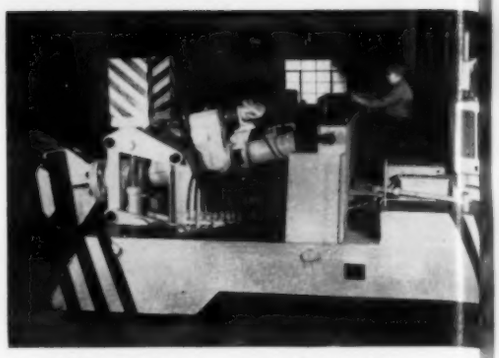
A recorder with a pen speed of 24 sec for full-scale response is used with the new measurement system. The pen speed is sufficient to follow any variations in temperature which may occur, and is slow enough so that the transients caused by field current changes will be minimized.

While this method of measurement is used mainly on a-c power generators, it can also be applied to field temperature measurements of d-c motors and generators, and synchronous motors, converters and condensers.

FORGING MANIPULATORS

▲ Announced by Salem-Brosius, Inc., is a new line of all-hydraulic forging manipulators.

The mobile manipulators are available in capacities ranging from 2,000 to 20,000 lb. They have newly developed mechanical and hydraulic shock-absorbing features designed

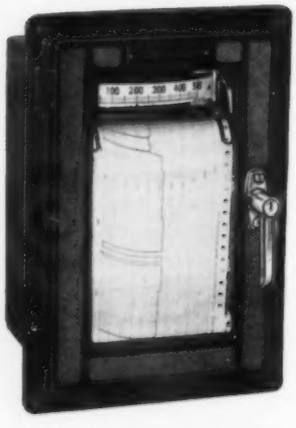


to withstand the severe shock characteristics resulting from manipulating metals of minimum plasticity during forging.

Available with diesel, gasoline, propane or plant power sources, the new manipulator has unlimited floor travel and all work handling motions are hydraulically actuated and controlled.

The manipulators are more rugged and promise to cut maintenance costs. They also offer these advantages: elimination of the need for cranes, conveyor tables, counterweights, hoists and other auxiliary equipment otherwise required for forge manipulating and for handling material between furnaces and presses; elimination of the need to

QUALITY is not an accident



Product Representatives in Most Principal Cities

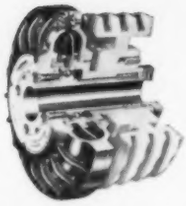
It cannot be copied.
It is not attained over night.

Quality is built into E-A Recorders by specialists—workmen whose livelihood depends upon quality and who have spent their lives making just this one product.

For over 50 years, E-A has made the best for those who want only the best in recorders.

Ask for Catalog CC854A

The ESTERLINE-ANGUS Company, Inc.
Pioneers in the Manufacture of Graphic Instruments
Dept. F4, P. O. Box 596, INDIANAPOLIS 6, INDIANA



FLEXIDYNE

THE DRY FLUID DRIVE

NEW! REVOLUTIONARY!

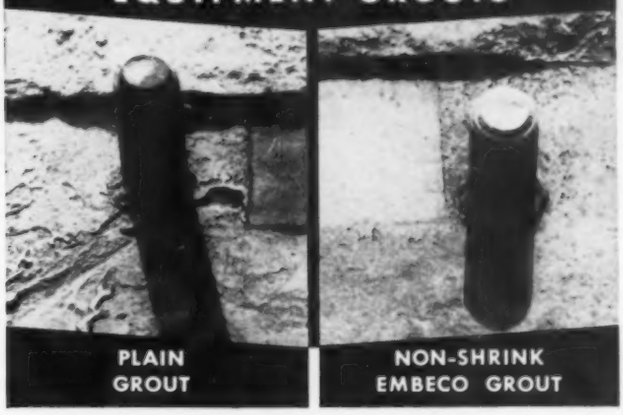
Handles difficult starting problems and gives a *new* kind of protection against shock and overloads. The dry flow-charge can be varied to give exact torque you need. When load reaches normal speed there is zero slip, giving 100% efficiency. Write for bulletin with detailed information on Flexidyne Drives and Flexidyne Couplings.

DODGE MANUFACTURING CORPORATION, 5900 Union St., Mishawaka, Ind.

DODGE

of Mishawaka, Ind.

COMPARE EQUIPMENT GROUTS



PLAIN GROUT

NON-SHRINK EMBECO GROUT

. . . And You'll See Why

EMBECO PRE-MIXED GROUT

gives *lasting* results on every equipment grouting job. Add only water to Embeco Pre-Mixed Grout, mix and place. Obtain a *flowable, non-shrink* grout that insures full bedplate contact, maintains alignment, has high impact resistance.

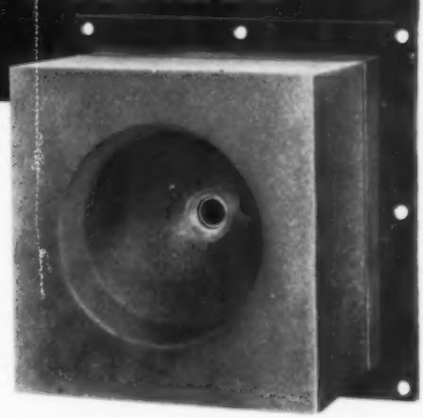
Write for Free Grouting Guide

DIVISION OF AMERICAN-MARIETTA COMPANY

the MASTER BUILDERS co.

CLEVELAND 3, OHIO TORONTO 9, ONTARIO

Large Radiant Heat Surface Provides High Rate of Heat Transfer

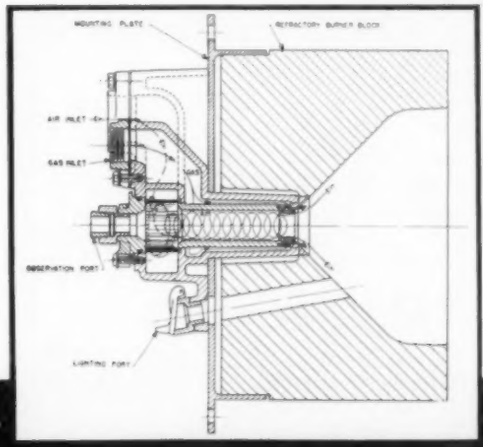


HAUCK Hi-Radiant Cone Gas Burner

Assures direct radiant heat processing for greater heat penetration without flame impingement

- Heating temperature to 2900° F.
- More than 10 to 1 turndown ratio
- Long, trouble-free performance
- Less burner maintenance
- Burner nozzle outlet of stainless steel
- Observation port
- Nozzle mixing of air and gas
- No backfiring, costly fire checks or mixers
- Uses low pressure air and gas
- Burns any fuel gas
- Reduces furnace size
- Six sizes— to 1.4 million Btu/Hr.

Write for Catalog 809



Series "RCG" Gas Burner for steel mill and non-ferrous heating furnaces.

Another in the extensive Hauck line of gas burners, oil burners, combination gas and oil burners, blowers, pumps and oil heaters.

HAUCK MANUFACTURING CO.

114-124 Tenth Street—Brooklyn 15, N. Y.

How about treating your family to a better chance against cancer?

You give your family the best of everything . . . all-day outings in the car, maybe a movie after, and then a soda to top it all off. There's really nothing you wouldn't do to make your family happy.

And if you could help make them safe . . . safe against cancer, you'd do that too, wouldn't you? And fast. Well, you *can* help. The American Cancer Society needs your dollars right now. It needs them for research, which is making important gains against the killer. For education, which gives everyone life-saving facts about cancer. For service, which aids and comforts the stricken.

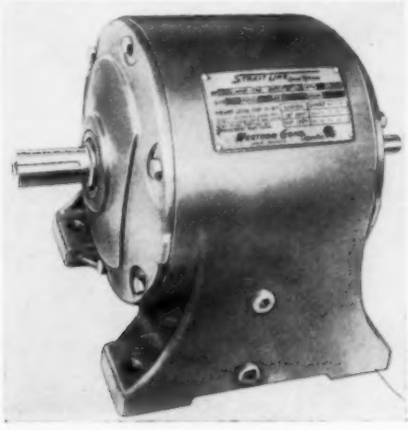
Don't skip the treats that make life pleasant for the family. But don't skip the chance to strike back at a disease that threatens them. Match the cost of that next outing with a check to the American Cancer Society. That's the most worth-while treat you could give! Send your check to "Cancer" in care of your local Post Office today.

AMERICAN CANCER SOCIETY

devote valuable floor space to tracks and conveyor tables or overhead area to cranes and craneways.

SPEED REDUCER

▲ Western Gear Corp. announces the design and manufacture of a new in-line series of speed reducers to be marketed under the trade name "StraitLine." These reducers are



available in double and triple reduction. Double reduction units are offered in 15 standard ratios from 3.39:1 to 57.3:1 with ratings up to 100 hp. Triple reduction units are available in 9 ratios from 82.1:1 to 190.7:1 with ratings up to 50 hp.

The reducers feature complete interchangeability of individual parts throughout frame sizes as well as packaged sub-assemblies.

THICKNESS CLASSIFIER

▲ Automatic inspection and assorting according to thickness of tin plate sheets at the rate of 60 to 100 sheets per minute is done with an Xact Ray Thickness Gauge in operation at the Indiana Harbor Works, Youngstown Sheet and Tube Co.

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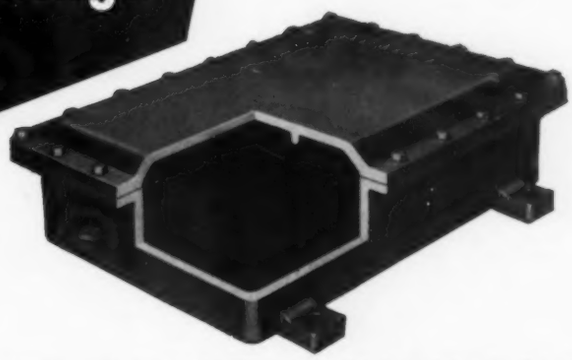

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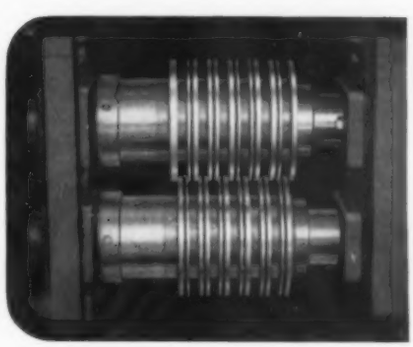

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tor the thickness of sheets rejected and passed.

The Youngstown Sheet and Tube installation of the thickness classifier is working on sheets with a minimum length of 16 in. and a maximum of 45 in., and a range of thickness from 0.006 to 0.019 in. Gaps between the sheets on the conveyor do not affect the operation.

SEMI-PRESSURE FANS

▲ Available from Aerovent Fan Co., Inc., are semi-pressure fans for efficient performance against static pressures normally considered above the range of propeller-type fans.

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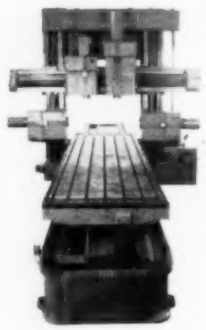

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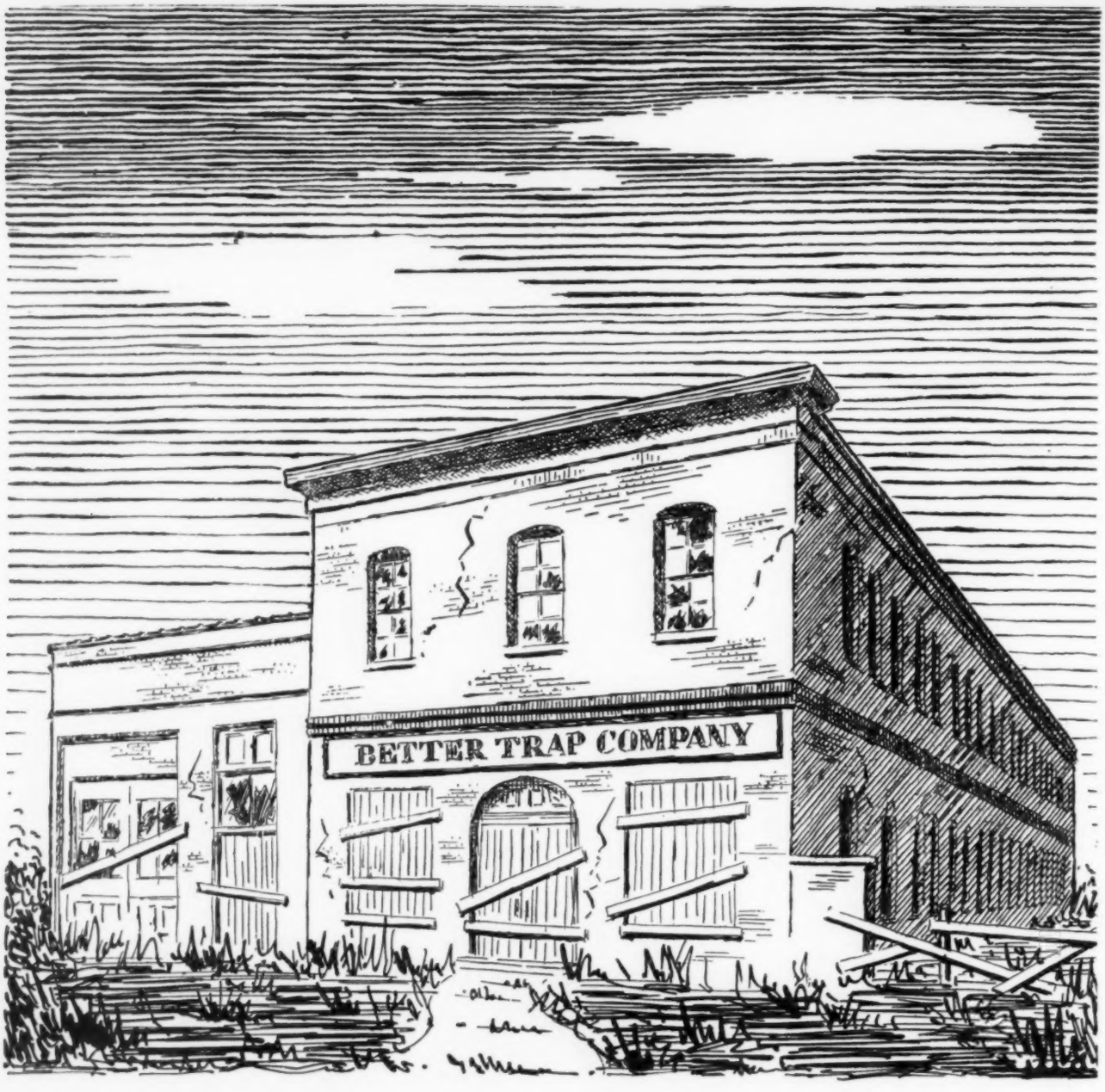

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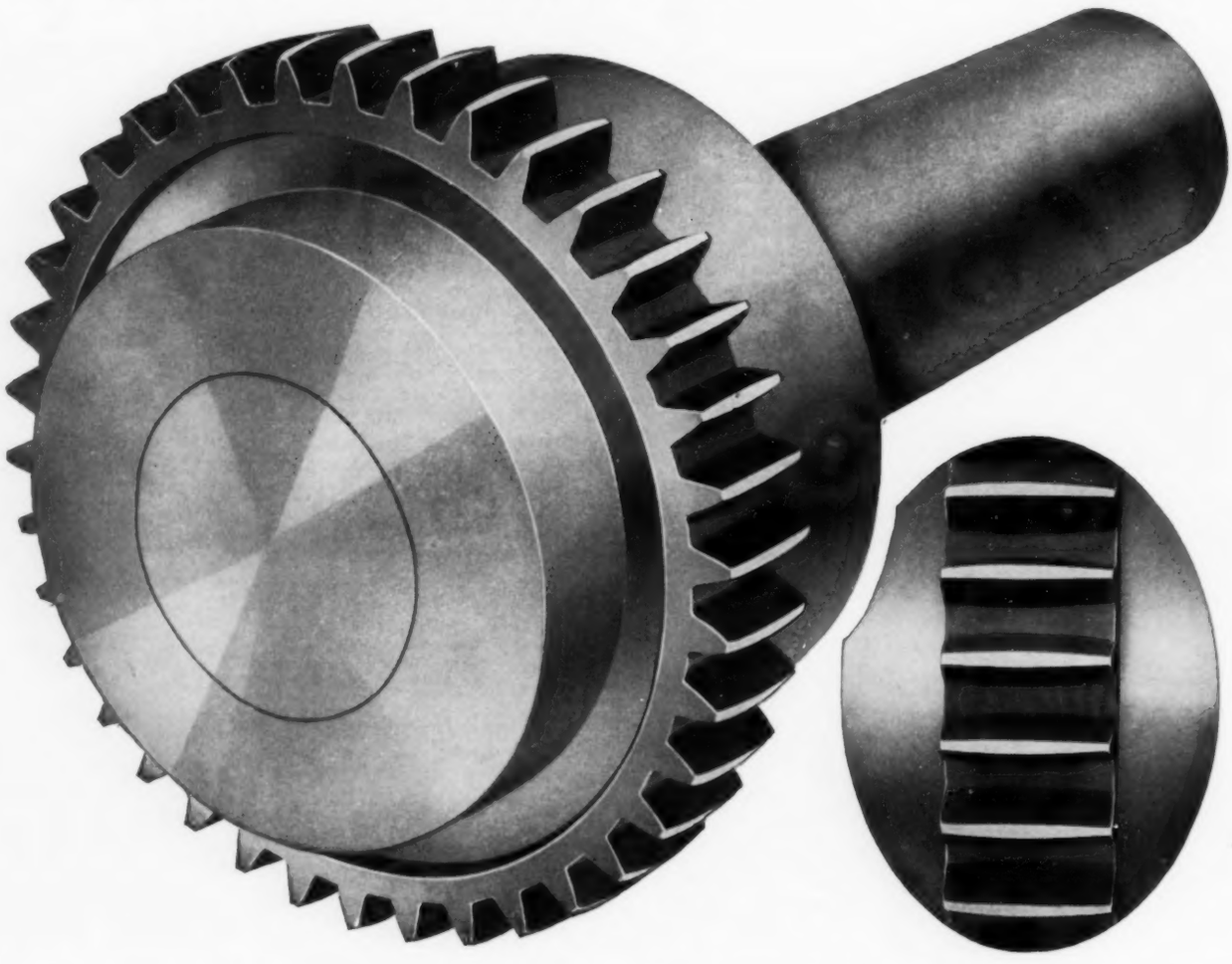

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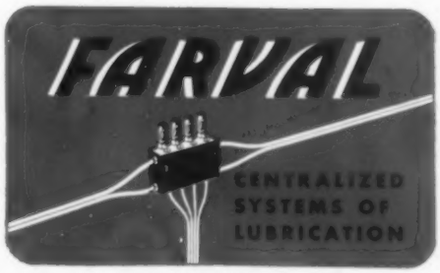

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